This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

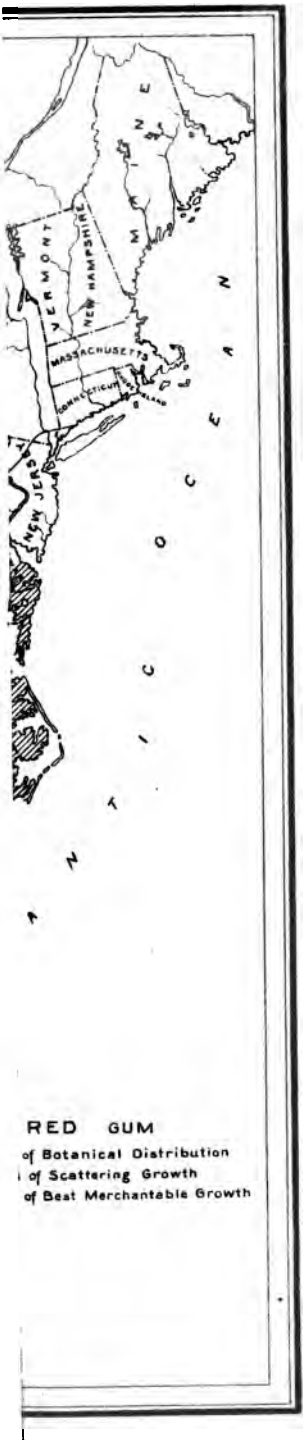
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`


MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
NEW JERSEY
ATLANTIC OCEAN
RED GUM
of Botanical Distribution
of Scattering Growth
of Best Merchantable Growth

SD
11
.A2
cop. 4

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF FORESTRY—BULLETIN No. 58.
GIFFORD PINCHOT, Forester.

THE RED GUM.

BY

ALFRED K. CHITTENDEN, M. F.,
ASSISTANT FOREST INSPECTOR, BUREAU OF FORESTRY.

WITH A DISCUSSION OF

THE MECHANICAL PROPERTIES OF RED GUM WOOD.

BY

W. KENDRICK HATT, Ph. D.,
CIVIL ENGINEER, BUREAU OF FORESTRY.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

FORESTRY DEPARTMENT

BUREAU OF FORESTRY.

GIFFORD PINCHOT, *Forester.*

FOREST MEASUREMENTS,
OVERTON W. PRICE, *in Charge.*

FOREST MANAGEMENT,
THOMAS H. SHERRARD, *in Charge.*

DENDROLOGY,
GEORGE B. SUDWORTH, *in Charge.*

FOREST EXTENSION,
ERNEST A. STERLING, *in Charge.*

FOREST PRODUCTS,
WILLIAM L. HALL, *in Charge.*

RECORDS,
JAMES B. ADAMS, *in Charge.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Forestry,
Washington, D. C., January 23, 1905.

Sir: I have the honor to transmit herewith a report entitled "The Red Gum," by Alfred K. Chittenden, M. F., Assistant Forest Inspector in the Bureau of Forestry, accompanied by a discussion of "The Mechanical Properties of Red Gum Wood," by W. Kendrick Hatt, Ph. D., Civil Engineer in the Bureau of Forestry, and to recommend its publication as Bulletin No. 58 of the Bureau of Forestry.

The map, six plates, and seven text figures accompanying the text are necessary for its proper illustration.

Very respectfully,

Gifford Pinchot, *Forester.*

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

THE RED GUM.

Page.

Introduction 7
The red, tupelo, and black gums 8
Occurrence of red gum 9
    The land 10
    Associated species 10
        In the Mississippi Valley 10
        On the Atlantic Coast 11
Characteristics of the red gum tree 12
    Form 12
    Tolerance 12
    Demands upon soil and moisture 13
    Reproduction 13
    Second growth 15
Hostile influences 15
    Windfall 15
    Fires 15
    Insects 16
    Fungi 16
    Other influences 16
Land values and stumpage 16
Lumbering 17
Market and uses 19
Properties of the wood 22
Prices of red gum lumber 23
Milling 24
Seasoning 24
Lumbering, manufacture, and uses of tupelo gum 26
    Logging 27
    Quality and uses 27
    Methods of handling 28
Rate of growth of red gum 28
Volume of red gum 30
Forest management 36

THE MECHANICAL PROPERTIES OF RED GUM WOOD.

Strength of red gum joists 40
Value of red gum for carriage stock 40
Tests on sticks from red gum bolts collected in the forest 42
Weight of red gum wood 49
Resistance to abrasion 50
The structure of red gum wood 50
    The wood fibers 52
    The ducts or vessels 53
    The medullary rays 53
Index 55

ILLUSTRATIONS.

MAP.

Page.
The distribution of red gum .... Frontispiece.

PLATES.

PLATE I. Fig. 1.—A large red gum, Richland County, S. C. Fig. 2.—Second-growth red gum, ash, cottonwood, and sycamore on hardwood bottomland, South Carolina 16
II. Fig. 1.—Tupelo gum slough, Congaree River, South Carolina. Fig. 2.—Hardwood bottom land recently logged, Richland County, S. C 16
III. Fig. 1.—Dense canebrake, South Carolina. Fig. 2.—Peeled red gum logs seasoning in the woods, South Carolina 20
IV. Fig. 1.—A large cottonwood in Richland County, S. C. Fig. 2.—A cypress slough in the dry season, South Carolina 20
V. Section from the butt of a red gum grown in Missouri, showing decay following injury by fire and insects 24
VI. Fig. 1.—One-inch red gum boards, kiln dried, showing proportion of warp and twist. Fig. 2.—Red gum boards, five-eighths inch sapwood, selects and No. 1 common, very free from check 24

TEXT FIGURES.

FIG. 1. Method of taking test pieces from red gum bolts secured at Hollywood, Ala 43
2. Method of taking test pieces from red gum bolts secured at Risco, Mo. 44
3. Characteristic fracture of red gum and hickory under torsion test 51
4. Cross section showing the structure of red gum wood 52
5. Elements of the structure of red gum wood 53
6. Comparative sizes of the wood elements of red gum 54
7. Cross section of a medullary ray in red gum 54

THE RED GUM.[a]

INTRODUCTION.

Only in the last few years has enough southern red gum been marketed to warrant the National Hardwood Manufacturers' Association in giving it a class and a special grading. Previous to this time the manufacture of gum was in an experimental stage, owing chiefly to its tendency to warp and twist, and also to the fact that the supply of other hardwoods was so large that there was no incentive to work so low-priced and supposedly unsatisfactory a wood as gum. Nevertheless, a few of the manufacturers, looking into the future, saw that the supply of the various finishing woods in use was limited, and that new woods would have to be sought. Red gum has been found to answer remarkably well, and with the increase in price of cottonwood and yellow poplar it has been gradually brought upon the market. Certain objectionable qualities have been found possible of elimination by judicious handling and care, and gum consequently now ranks as a commercial wood with a recognized standing.

Red gum grows in mixture with ash, cottonwood, and oak throughout the hardwood bottomlands of the South. These rich, alluvial bottoms are among the best natural farming lands of the region. In the past the gum, having no marketable value, has been left standing after logging, or, where the land has been cleared for farming, has been girdled and allowed to rot, and then felled and burned as trash. Not only were the trees a total loss to the farmer, but from their size and the labor required to handle them, they were so serious an obstruction as often to preclude the clearing of valuable land. Now, however, that there is a market for the timber it will be profitable to cut the gum with the other hardwoods, and land can be cleared more cheaply. This increase in the value of gum timber will also bring more sawmills into the South, and in many ways is going to be of great benefit to the Southern landowner. In logging operations, now that practically all of the hardwoods are merchantable, a cleaner lumbering job can be made, and the value of the land for forest management will be greatly increased. Where only a few trees in the forest are of merchantable value, forest management is out of the question; where nearly all are of value it will often pay to hold the land for a second crop.

---

[a] Also called sweet gum and star-leafed gum.

The measurements on which the tables in this study are based were made by field parties of the Bureau of Forestry in two localities—in New Madrid County, Mo., on the lands of the Himmelberger-Harrison Lumber Company, and in South Carolina, on lands on the Congaree River, owned by the Santee River Cypress Lumber Company. The courtesy of these two companies made possible the obtaining of the data. In addition to this work a study was made of the habit and reproduction of the gum throughout the South, together with a study of milling methods, handling, and market conditions. The market conditions were studied by Mr. H. D. Hartley.

The tables in this report apply quite generally to the range of the species, those for Missouri holding good, with little variation, for the Mississippi River States, and those for South Carolina applying in general to the Atlantic coast region. It will be seen that the tree differs greatly in rate of growth, percentage of sapwood, and volume in these two localities. Intermediate variations between these two types of course occur. It should be remembered, however, that these tables for gum apply only on hardwood bottomlands.

THE RED, TUPELO, AND BLACK GUMS.

There are three important species of gum in the South. The principal one is the red gum, usually called by lumbermen simply "gum." The tupelo gum, which is known as tupelo and as bay poplar, is also of commercial value. The third species, black gum, is not cut as mill timber, owing to its less abundant supply and poorer quality, but finds employment for repair work on wagons, for cattle yokes, and for other uses which require a strong, non-splitting wood.

All three of these gums are Southern woods, and grow for the most part in the district bounded on the north by the Potomac and Ohio rivers. They extend as far west as Kansas, south through Missouri, Louisiana, and the eastern part of Texas to the Gulf, and east to the Atlantic Coast. Throughout this region red gum is the most common of the three.

Red gum (*Liquidambar styraciflua*) is distributed from Fairfield County, Conn., to southeastern Missouri, through Arkansas and the Indian Territory to the valley of the Trinity River in Texas, and eastward to the Atlantic Coast. Its commercial range is restricted, however, to the moist lands of the lower Ohio and Mississippi basins and of the southeastern coast. It is one of the commonest trees throughout the hardwood bottom type of forest, and reaches a large size. It is found also to a considerable extent on the uplands and low ridges, but is there scattered and of smaller size.

Tupelo gum (*Nyssa aquatica*) occurs throughout the coastal region of the Atlantic States from southern Virginia to northern Florida, through the Gulf States to the valley of the Nueces River in Texas, through Arkansas and southern Missouri to western Kentucky and Tennessee, and to the valley of the lower Wabash River. Few large bodies of merchantable tupelo are found, however, except in the vicinity of Mobile, Ala., where the tree attains its best growth. The country in this locality is very swampy, and, within a radius of 100 miles, tupelo gum is one of the principal timber trees. It grows only in the swamps and wetter situations, often in mixture with cypress, and, in the rainy season, it stands in from 6 to 20 feet of water.

Black gum (*Nyssa sylvatica*) is distributed from Maine to southern Ontario, through central Michigan to southeastern Missouri, southward to the valley of the Brazos River in Texas, and eastward to the Kissimmee River and Tampa Bay in Florida. It is found in the swamps and hardwood bottoms, but is more abundant and of better size on the slightly higher ridges and hummocks in these swamps, and on the mountain slopes in the southern Allegheny region. Though its range is greater than that of either the red or tupelo gum, black gum nowhere forms an important part of the forest.

OCCURRENCE OF RED GUM.

Red gum is perhaps the commonest timber tree in the hardwood bottoms and drier swamps of the South. It is found also to a considerable extent on the low ridges and slopes of the southern Appalachians, but there it does not reach merchantable value and is of little importance.

The hardwood bottoms are for the greater part overflow land. The soil is alluvial and generally of great fertility, and tree growth is for the most part extremely rapid. When such alluvial lands are cleared they form some of the richest farming land in the country. These hardwood bottoms stretch along nearly all of the Southern rivers on the coastal plain and in the Mississippi Valley States. They are subject to heavy floods in the winter and spring, for the rivers, rising among the mountains, run swiftly until they reach the general plain level, so that any increase in the volume of water is bound to overflow the banks and spread out over the entire width of the bordering swamp, often to a considerable depth. These bottomlands vary considerably in width, but are usually from 6 to 12 miles wide, and are bounded by the sharp banks of the upland plain, the river meandering through the swamp from one bank to the other.

Considerable difference is found between the growth in the upper Mississippi bottoms and that along the rivers on the Atlantic coast and on the Gulf. In the latter regions the bottoms are lower, and consequently more subject to floods, and to continued overflows. The alluvial deposit also is greater, and the trees grow considerably faster. Trees of the same diameter show a larger percentage of sapwood there than in the upper portions of the Mississippi Valley. The Mississippi Valley hardwood trees are for the most part considerably older, and reach larger dimensions than the timber along the coast.

The composition of the forest, however, is quite similar throughout, although, owing to the large number of species, no tables of the yield of merchantable timber can be made that will be of general application. In any hardwood forest the percentage of each species in mixture varies so greatly, even in the same locality, that figures for the stand per acre must be made for each separate tract under consideration. General estimates of yield per acre will only be an approximation of what may be expected under usual conditions.

THE LAND.

Hardwood bottomland in Missouri is practically flat. The elevation above the ordinary level of the Mississippi River varies from 10 to 20 feet. The whole region was formerly subject to inundation from the river and its tributaries, but ditches and levees now protect a considerable part from these overflows.

The soil is made up of alluvial deposits of sand and clay. It is of great depth and with no outcrop of underlying rock; but at an average depth of 15 feet below the surface a hard-pan is usually found. The top soil, formed by admixture with organic matter, is a deep loamy sand or clay loam, according as sand or clay subsoil prevails. The undrained forest soil is wet in winter and moist in summer, but where the land has been cleared and drained the soil remains wet only a very short time, and in the hot months it becomes rather dry. Decomposition is extremely rapid in these bottoms, and there is very little humus. In the forest there is usually a layer of from 3 to 6 inches of organic soil.

The soil is extremely fertile, and the land is always valuable for agriculture when cleared and drained. It is only a question of time until this entire region will be devoted to agriculture. The principal crops are corn, wheat, cotton, oats, alfalfa, potatoes, and timothy and clover. The land yields an average of 30 bushels of corn to the acre, and some of it yields in good years as much as 80 bushels.

ASSOCIATED SPECIES.

IN THE MISSISSIPPI VALLEY.

Uncleared bottomlands are covered with heavy stands of mixed hardwood timber. In the Mississippi Valley States red gum predominates, in mixture with oaks, elms, white ash, red maple, and hackberry. There are three common forest types, called by the lumbermen slough, glade, and ridge bottoms. The slough bottom is wet throughout the year, and the glade bottom during the winter and spring months, while the ridge bottom is very seldom covered with water. A difference of 1 or 2 feet in elevation changes one type into another.

The glade bottom is by far the most prevalent type, and of the greatest interest. This land, when undrained, is covered with water for about five months of the year—from January through May; the remainder of the year it is usually dry. Its characteristic forest growth consists of the following species, arranged in order of their representation: Red gum, red maple; cow, red, shingle, overcup, and willow oak; elm, sassafras, hackberry, papaw, dogwood, and blue beech. The forest is usually dense, and the trees are of large diameter and great age.

What are locally known as ridges occur in the glades. They are elevations of a few feet only, where there is seldom or never any standing water. Red gum is here also predominant, with oaks, and mockernut, shagbark, and pecan hickories next in the order mentioned. There is also often considerable black gum. Other species found are elm, red maple, sassafras, hackberry, dogwood, papaw, and white ash. Growth is a little slower than in the glades, and the forest is rather less dense. Far to the south these ridges are covered with a thick growth of cane.

The composition of the forest in the sloughs varies considerably. Most frequently it consists of cypress and tupelo gum, either in pure stands of one or the other, or a mixture of the two. But little red gum is found in them. Sometimes, however, the sloughs contain nearly all of the species common to the glade type, with cypress and tupelo in addition. The forest is nearly always very dense.

ON THE ATLANTIC COAST.

The bottomlands of the rivers along the Atlantic coast are very similar in character to those in Missouri, except that they are more subject to floods, and the ridge type of forest is less common. The forest on the hardwood bottoms of the Congaree River, in South Carolina, consists chiefly of red gum, cottonwood, white ash, elm, sycamore, hackberry, some few oaks, and red and silver maples. In the sloughs and perpetual swamps are large quantities of cypress and tupelo gum, and there is some black gum on the ridges. The forest is, for the most part, dense and fairly even-aged. There is little young growth beneath the older trees. (Pl. IV.) Canebrakes are common and are very dense, the cane often reaching a height of 20 feet. This cane, with the briers and rattans, makes a very heavy undergrowth, so that where it occurs no tree reproduction can take place. (Pl. III, fig. 1.) The result is that the forest gradually becomes rather open in character.

The forests farther south are very similar in general mixture of species to those just described. There is, however, considerable hackberry and red mulberry, and the trees are usually of larger size than in the North. The ground cover consists largely of Spanish bayonet, and the canebrake is apt to be very dense. In the bottomlands of southern Georgia and northern Florida there are often considerable groups of palmettos around the edges of the sloughs. These palmettos reach a height of 30 feet and a diameter of 8 or 10 inches. In the wetter swamps, tupelo gum and cypress are very abundant.

CHARACTERISTICS OF THE RED GUM TREE.

FORM.

In the best situations red gum reaches a height of 150 feet and a diameter of 5 feet. These dimensions, however, are unusual. The stem is straight and cylindrical, with dark, deeply furrowed bark, and branches often winged with corky ridges. In youth, while growing vigorously under normal conditions, it assumes a long, regular, conical crown, much resembling the form of a conifer. After the tree has obtained its height growth, however, the crown becomes rounded, spreading, and rather ovate in shape. When growing in the forest the tree prunes itself readily at an early period, and forms a good length of clear stem, but it branches strongly after making most of its height growth. The mature tree is usually forked, and the place where the forking commences determines the number of logs in the tree, or its merchantable length, by preventing cutting to a small diameter in the top. On large trees the stem is often not less than 18 inches in diameter where the branching begins. The overmature tree is usually broken and dry-topped, with a very spreading crown, in consequence of new branches being sent out. Injury to the butts of trees from fire and to the tops from wind or ice often opens the way to attacks from fungi, which cause decay, and from insects, which precede and assist the fungi. (Pl. V.)

The root system of the red gum differs considerably in various localities. As a rule the tree on hardwood bottomland has a fairly well developed taproot and strong, branching lateral roots. On the ridges and on pine land the root system is deeper, with a very large and long taproot and long superficial roots. In the sloughs and swamps the taproot is absent, and the root system is flat and very spreading, with small, branching laterals.

TOLERANCE.

Throughout its entire life red gum is intolerant of shade. There are practically no red gum seedlings under the dense forest cover of the bottomland, and while a good many may come up under the pine forest on the drier uplands, they seldom develop into large trees. As a rule seedlings appear only in clearings or in open spots in the forest.

It is seldom that an overtopped tree is found, for the gum dies quickly if suppressed, and is consequently nearly always a dominant or intermediate tree. In a hardwood bottom forest the timber trees are all of nearly the same age over considerable areas, and there is little young growth to be found in the older stands. The reason for this is the intolerance of most of the swamp species. A scale of tolerance containing the important species, and beginning with the most light-demanding, would run as follows: Cottonwood, sycamore, red gum, white elm, red oak, white ash, red maple.

From this it will be seen that red gum is one of the more intolerant species occurring on these lands. Cottonwood, which along the coast is its chief competitor, is of extremely rapid growth and seldom reaches great age, although in size it surpasses the red gum. (Pl. IV, fig. 1.) It tends to reproduce in groups or clumps, and, by its own more rapid growth, it shades out the other intolerant species. With it is mixed ash, which, by reason of its greater tolerance, is able to live during youth in the shade cast by the cottonwood. But little reproduction of any of the merchantable species is found after lumbering, for the forest is seldom opened up sufficiently to permit the seedlings to live.

DEMANDS UPON SOIL AND MOISTURE.

While the red gum grows in various situations, it prefers the deep, rich soil of the hardwood bottoms, and there reaches its best development. It requires considerable soil moisture, though it does not grow in the wetter swamps, and does not thrive on dry pine land. Seedlings, however, are often found in large numbers on the edges of the upland and even on the sandy pine land, but they seldom live beyond the pole stage; when they do, they form small, scrubby trees that are of little value. The variation in the root system already noted is an adaptation to the moisture conditions. Where the soil is dry the tree has a long tap-root. In the swamps, where the roots can obtain water easily, the development of the tap-root is poor, and it is only moderate on the glade bottomlands, where there is considerable moisture throughout the year, but no standing water in the summer months.

REPRODUCTION.

Red gum reproduces both by seed and by sprouts. It produces seed fairly abundantly every year, but about once in three years there is an extremely heavy production. The tree begins to bear seed when 25 or 30 years old, and seeds vigorously up to an age of 150 years, when its productive power begins to diminish. A great part of the seed, however, is abortive. Mr. George B. Sudworth, of the Bureau of Forestry, places the germinating power of fresh red gum seed at between 50 and 75 per cent.[a] This, however, would seem rather too high an average for forest conditions.

Red gum is not fastidious in regard to its germinating bed; it comes up readily on sod in old fields and meadows, on decomposing humus in the forest, or on bare clay-loam or loamy-sand soil. It requires a considerable degree of light, however, and prefers a moist seedbed. The natural distribution of the seed takes place for several hundred feet from the seed trees, the dissemination depending almost entirely on the wind. A great part of the seed falls on the hardwood bottoms when the land is flooded, and is either washed away or, if already in the ground and germinating, is destroyed by the long-continued overflow.

After germination, the red gum seedling demands, above everything else, abundant light for its survival and development. It is for this reason that there is very little young growth of red gum, either in the unculled forest or on culled lands, where, as is usually the case, a dense undergrowth of cane, briers, and rattan is present. Under the dense underbrush of cane and briers throughout much of the virgin forest, reproduction of any of the merchantable species is of course impossible (Pl. III, fig. 1), and even where the land has been logged over the forest is seldom open enough to allow reproduction of the cottonwood and red gum. Where, however, seed trees are contiguous to pastures or cleared land, scattered seedlings are found springing up in the open, and where openings in the forest occur there are often large numbers of red gum seedlings, the reproduction generally occurring in groups. But over the greater part of the Southern hardwood bottomland, forest reproduction is extremely scanty.

The growth of red gum during the early part of its life and up to the time it reaches a diameter of 8 inches breasthigh is extremely rapid, and, like most of the intolerant species, it attains its height growth at an early period.

Gum sprouts readily from the stump, and the sprouts surpass the seedlings in rate of height growth for the first few years, but they seldom form large timber trees. The capacity to sprout when cut is confined to the younger trees. Those over 50 years of age seldom sprout. For this reason sprout reproduction is of little importance in the forest.

The principal requirements of the red gum, then, are a moist, fairly rich soil and good exposure to light. Without these it will not reach its best development.

---

[a] The Forest Nursery: Bulletin 29, Bureau of Forestry.

SECOND GROWTH.

Second growth red gum occurs to any considerable extent only on land which has been thoroughly cleared. Throughout the South there is a great deal of land which was in cultivation before the war, but which during the subsequent period of industrial depression was abandoned and allowed to revert to forest. These old fields are now mostly covered with second-growth forest, of which red gum forms an important part. (Pl. I, fig. 2.) Frequently over 50 per cent of the stand consists of this species, but more often, and especially on the Atlantic coast, the greater part is of cottonwood or ash. These stands are very dense and the growth is extremely rapid. Small stands of young growth are also often found along the edges of cultivated fields.

In the Mississippi Valley the abandoned fields on which young stands have sprung up are, for the most part, being rapidly cleared again. The second growth here is considered of little value in comparison with the value of the land for agricultural purposes. In many cases, however, the farm value of the land is not at present sufficient to make it profitable to clear it, unless the timber cut will at least pay for the operation. There is considerable land upon which the second growth will become valuable timber within a few years. Such land should not be cleared until it is possible to utilize the timber.

HOSTILE INFLUENCES.

The forests of the hardwood bottomlands are particularly free from injurious influences, and, except in a few cases, little fear need be entertained of loss of standing timber. The principal causes of injury to forest trees are windfall, fire, insects, and fungi.

WINDFALL.

Windfall is rare on the hardwood bottoms. The red gum has a very strong root system, and, growing as it does on heavy soil and in an absolutely flat location, it is seldom wind-thrown. There is, moreover, little exposure to wind, as the trees vary little in height and there are no hills, slopes, or exposed places in the forest. Even when growing on the lighter soil of the pine land, the gum is seldom wind-thrown.

FIRES.

Throughout the greater part of the year, the soil of the bottomlands is too wet to permit the spreading of fire. This is particularly true of the spring, during which fires are very common on pine land, while the bottoms are often flooded. These forests, however, are dry during the summer months, and in many localities they are then burned over to improve the grazing. The fires do great damage to the butts of many of the trees, and have a general debilitating effect on the forest. With the exception of the red maple, red gum appears to be more susceptible to such injury than any other of the species present.

Fires do much damage also by destroying the reproduction and thereby increasing the amount of weeds, briers, and worthless undergrowth. They likewise destroy the humus and leaf litter and tend to lessen the density of the forest, as well as to facilitate the attack of insects and fungi. The hardwood bottom forests are, however, probably freer from destructive fires than any other type of forest, and with a little care they can be made practically exempt.

INSECTS.

Fire-scarred butts of the trees are often attacked by wood-boring insects, rendering them further susceptible to decay, which frequently creeps for 6 feet up the trunk and hollows it out. (See Pl. V.) Decay induced by insects is also very common in the upper part of broken-topped, dry-topped, or overmature trees, and sometimes extends down to the beginning of the crown.

The subject of insect enemies of the red gum is receiving attention by the Bureau of Entomology, and will be fully treated in a forthcoming bulletin of that Bureau.

FUNGI.

Some eighty different species of fungi have been found on the red gum, but none of them is of a very injurious character. They usually follow injury by fire, wind, or insects, and tend to make the damage caused by these agencies more pronounced.

OTHER INFLUENCES.

In addition to the damage done to the trees by the agencies mentioned, very considerable injury is caused to the forests by the ranging of hogs and goats. They chiefly harm the young growth and reproduction. The hogs root up and eat the seeds before they germinate, and seedlings are often eaten by the goats, or stripped of their foliage and killed. Little satisfactory reproduction can be expected unless the ranging of hogs and goats is restricted during those periods when it is desired.

LAND VALUES AND STUMPAGE.

Practically all the best timberlands of the South are now controlled by large real-estate companies with headquarters in St. Louis, Memphis, Chattanooga, and large cities in the North. These companies are from ten to twenty years old, and were formed by men who, realizing the future value of these lands, bought them when the prices were

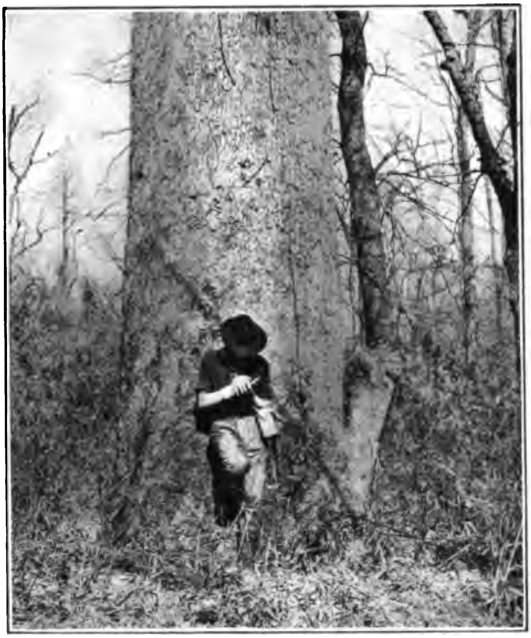


FIG. 1.—A LARGE RED GUM, RICHLAND COUNTY, S. C.

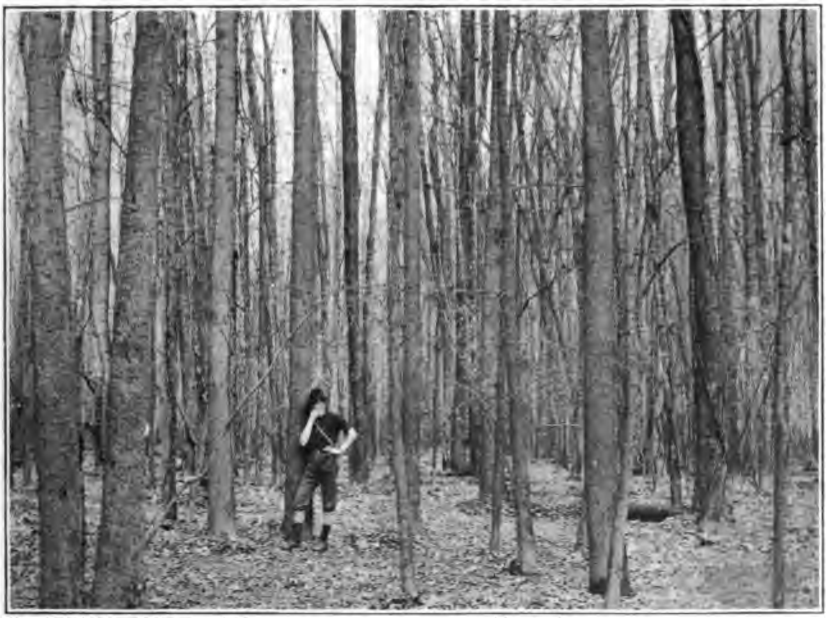


FIG. 2.—SECOND-GROWTH RED GUM, ASH, COTTONWOOD, AND SYCAMORE, ON HARDWOOD BOTTOM LAND, SOUTH CAROLINA.

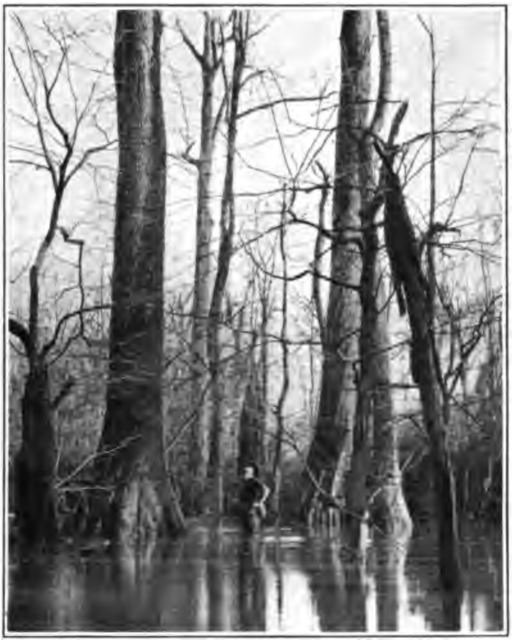


FIG. 1.—TUPELO GUM SLOUGH, CONGAREE RIVER, SOUTH CAROLINA.

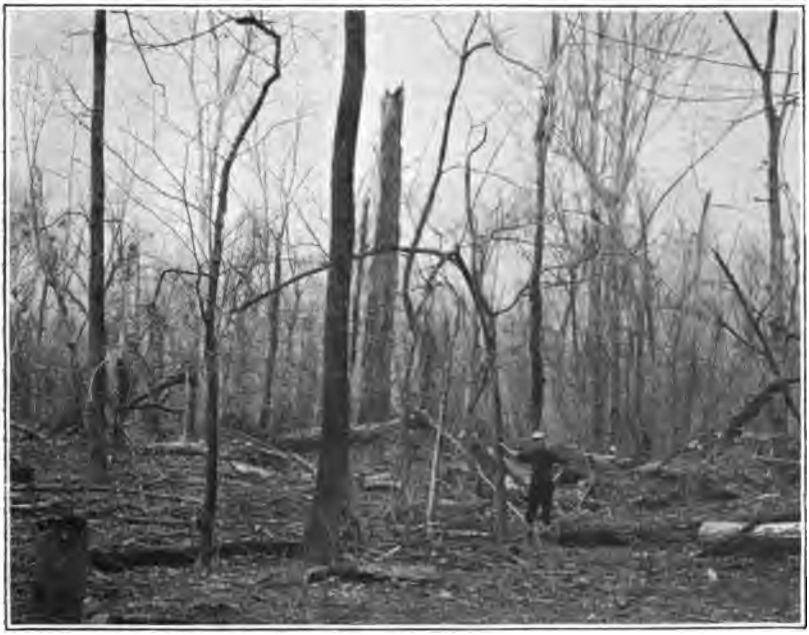


FIG. 2.—HARDWOOD BOTTOM LAND RECENTLY LOGGED, RICHLAND COUNTY, S. C.

greatly below their present valuation. It is now almost impossible to buy hardwood land in the Mississippi Valley for less than from $4 to $7 per acre, the price depending upon the location and the nearness to railroads or streams which furnish an easy outlet for the timber.

Gum timber ranges in value from 50 cents to $1.50 per 1,000 feet B. M. on the stump. Where the haul is very short and the timber exceptionally good as much as $2 per 1,000 board feet has been paid for stumpage. The land companies either log the land themselves or sell the stumpage to the sawmills. After the timber is cut, and the land made more valuable by their improvements, they sell it for from $10 to $18 per acre. In consequence of the exceptionally high quality of the land for agriculture, large amounts of hardwoods are now being cut in the South, opening up much new farming land. Landowners who have not already disposed of their holdings to timber or real-estate companies are now finding a ready sale for their gum logs at from $5 to $7 per 1,000 board feet, delivered at the mills. This allows from $4 to $5 for handling, and furnishes a very profitable employment for labor.

LUMBERING.

A large amount of red gum growing in the South can be economically transported from the forests to the mills only by means of the streams, owing to the expense of putting in railroads solely for the timber. Green red gum, however, is so heavy that it scarcely floats. Probably one-third of the logs, those with the largest amount of sapwood, sink. On the coast, where the percentage of sapwood is larger than in the Mississippi States, very few of the logs will float.

To overcome this difficulty, various methods of driving the sap out of the logs before they are thrown into the river have been tried, among them girdling the trees and allowing them to die, and peeling the logs and letting them lie two or three months before they are floated. It has been found by experience, however, that these methods cause the sapwood to decay by exposing it to the air and weather, and thus destroy much of the marketable value of that part of the tree. In the bottomlands of South Carolina, and in some localities in Mississippi, the trees are frequently cut in the fall and early winter, the bark is peeled off, and the logs left for about three months in the woods to dry out before they are floated to the mills. (Pl. III, fig. 2.) This method renders the log floatable, but it also is liable to cause the decay of the sapwood.

The increase in the value of sapwood which has taken place in the last few years has led to the adoption of a different procedure. The method of getting the logs ready for the river now principally followed in the South, is to cut the trees, without girdling, in the fall of the year, or from as early as the first of September until the time when high water sets in, which is usually from the first of January to the first of February. At that season the sap is down and the wood is as light as it ever will be while the tree is standing. When felled, the tree is cut into standard lengths; the logs are then skidded to the bank of the river, and tied in rafts with cypress, ash, or cottonwood, to keep them from sinking, and floated down to the mill as soon as high water comes.

Where railroad logging can be practiced, as in southeastern Missouri, the work is much simpler. Steam skidders are used in getting the logs to the tram. They are then loaded upon the cars with a steam log loader and carried directly to the mill pond. The average cost is about $1 per thousand board feet for felling, $3 for yarding, and about $1 per thousand for railroading over 20 miles of track, or a total cost in the mill pond of about $5 per thousand board feet, exclusive of stumpage.

The red gum which is now being cut is comparatively easy to remove from the woods. It is usually located within 1 or 2 miles of the river or railroad to which it must be hauled. Otherwise it could not be handled profitably at present prices. Beyond this there lies a supply, the amount of which is only vaguely known, which is unprofitable to cut. It is therefore impossible to estimate the total amount of this timber.

The timber now being cut for the market is chiefly that lying along the streams flowing into the Mississippi River, from the Ohio on the north to the Yazoo on the south. Such streams as the St. Francis, Wolf, and Arkansas have large tracts of overflow land, usually extending from 5 to 10 miles from the river on either side, which are now being cut over. In about twelve years all the timber from these lands will probably have been removed. The bottomlands of the Tennessee, Cumberland, and other streams flowing into the Ohio from the south have a stand of the same quality and density as the Mississippi River bottoms, but these fields have not as yet been so extensively opened up. Gum is also being cut on some of the rivers flowing into the Atlantic Ocean. The timber in this region is not so good as that in the Mississippi Valley, but as it is near a market which can consume a large amount of sapwood, lumbermen are finding a ready sale for it.

In the early history of red gum it was thought by many mill men that if the tree was girdled one year, allowed to die, and afterwards cut, the amount of red or heart wood would be increased. This was based on the theory that the darker color of the heartwood was caused by the death of the sapwood, and that killing the tree would tend to change the sap into heart. This theory has been abandoned, and in cutting gum little girdling is now done for this purpose. In selecting trees for cutting, the logger at the present time takes those with doty tops, rotten stumps, and heavy bark—indications of an old tree which contains a very small proportion of sapwood. These trees are found mainly in the drier situations, and usually measure from 40 to 60 inches in diameter. In the lower, wetter situations, and where the land is frequently overflowed, the trees have more sapwood and are of rather smaller size, although of faster growth, and do not seem to reach so great an age as on the drier land. With the exhaustion of the supply of this choicest timber, which must soon take place, it will become necessary to cut the sappier trees. Already there is a good demand for the lumber from them. With the growing scarcity of yellow poplar, cottonwood, and other cheap finishing woods, the demand for gum will steadily increase. Owing to the large supply of this timber in the Southern forests the price will doubtless remain about where it is, for a few years at least. After this, since the supply of gum will diminish and since the younger trees can not be used for the same purposes for which the older ones have been, red gum will increase rapidly in value.

MARKET AND USES.

The demand for red gum has increased very rapidly in the last six years. It is now used for practically all purposes which poplar and cottonwood have filled heretofore. Clear wood can be obtained cheaply in wide boards, an advantage which, with that of freedom from odor and taste, has been peculiar to poplar and cottonwood. The increasing scarcity of these latter woods, however, necessitated a substitute for them, and red gum seems to have filled this need admirably. The lumber mills which were cutting hardwoods had very little difficulty in adding gum to their product, and realizing that red gum was receiving much attention in manufacture, and that it was a timber easily secured, they did everything in their power to establish it on the market. This was in the years 1900-1902. As a result a number of new uses were found for the wood and the price was advanced. Lumbermen saw a large profit in it, and in the fall of 1903 the market was crowded with gum lumber. In the spring of 1904 the lumber yards in the St. Louis and Memphis districts were thoroughly stocked with red gum, and the sawmills lessened their cut of this wood until the supply in the open market should diminish. Owing to the fact that the competing hardwoods are growing scarce and advancing in price, this supply of gum is being quickly exhausted, and the mills are again sawing it.

The best grades of lumber, No. 1 and No. 2 clear heart, find a market almost exclusively in the export trade, though a small amount is used in this country for inside finishing. The commons and other clear sap go into cheap furniture, desks, the better grade of boxes, and a number of novelties. The poorer stock, which is practically log run, goes into boxes, barrels, and other articles for which short, narrow boards can be used. The inner portion of the hearts of the trees, which are of little value for boards on account of shakes and other defects, are usually sawed into 2 by 4 to 2 by 12, and sometimes 6 by 6 and 6 by 8 inch building timbers. These timbers have small value in the large markets, but near the mills the local trade exhausts the supply. (See page 40.)

Practically 60 per cent of the stock coming from the tree is commons or sap grade. This finds an almost exclusive use in the manufacture of boxes, for which it has been employed for the last six years, taking the place of cottonwood, pine, poplar, and sycamore, the latter used for tobacco boxes. The export trade of gum timber consists of clear heart, 6 inches wide and over, and of all thicknesses from three-eighths of an inch up to 2 inches. Practically 75 per cent of the clear-heart gum lumber cut in this country is exported for use in England, France, and Germany for the manufacture of furniture and inside furnishings, newel posts, stair railings, etc. In England the wood is commonly called satin walnut. The export timber is usually dried in our yards from sixty to ninety days, and upon its receipt abroad it is given a further air-drying for from six to eight months, or is kiln-dried.

In this country a constantly increasing quantity of red gum is used in the manufacture of furniture. The commoner grades are made into drawers, frames, and backing, for desks, bedsteads, tables, etc. Considerable clear heart is used also for surface work, either solid or as veneer. The natural color of the wood is attractive, but it takes stain so well that it is often made to imitate mahogany, oak, walnut, etc. The furniture factories in the cities use annually between 40,000,000 and 60,000,000 board feet of this lumber, figures which show that red gum is becoming a thoroughly established wood in the market.

A sewing-machine company at Cairo, Ill., uses 15,000,000 board feet of gum per year in the manufacture of sewing-machine tables. The wood is built up of three $\frac{3}{16}$-inch pieces, laid crosswise to each other to prevent warping, and usually finished with oak or other hardwood veneer. This method has been found very satisfactory.

One of the most important uses of red gum is for interior finish. Stained or in its natural color, it may be made very attractive, and when properly seasoned fulfills every requirement of a first-class wood for that purpose.

If used for siding, or in any place exposed to the weather, sapwood must be excluded or kept covered with paint.

For the manufacture of slack barrels red gum is now one of the most important woods in the country. Practically all of the manufacturers of staves, headings, and hoops in the Mississippi Valley are using gum. Up to the year 1900, elm and a little cottonwood were used for

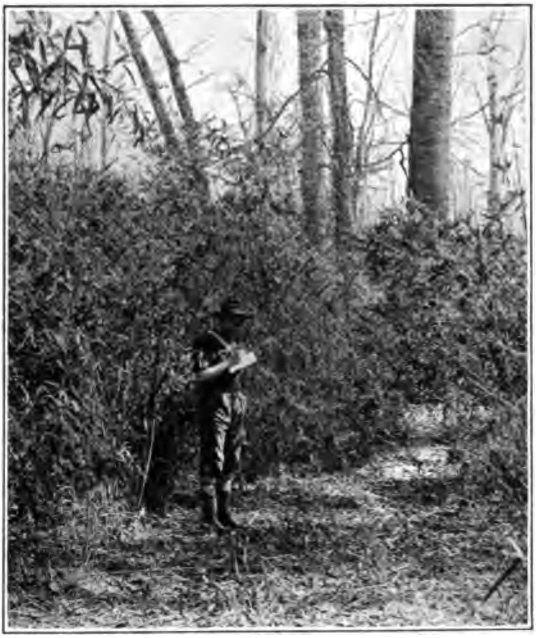


FIG. 1.—DENSE CANEBRAKE, IN WHICH NO TREE REPRODUCTION CAN TAKE PLACE, SOUTH CAROLINA.

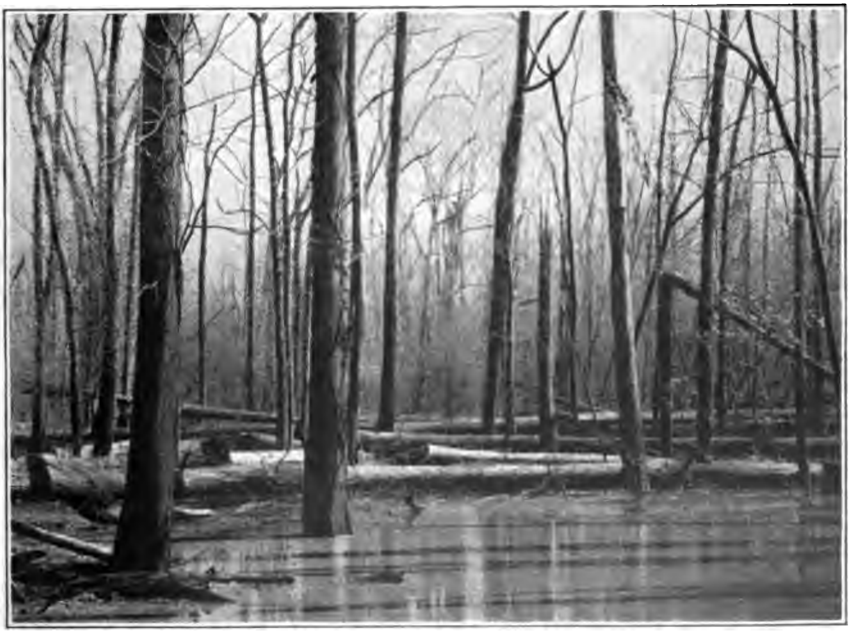


FIG. 2.—PEELED RED GUM LOGS SEASONING IN THE WOODS, SOUTH CAROLINA.

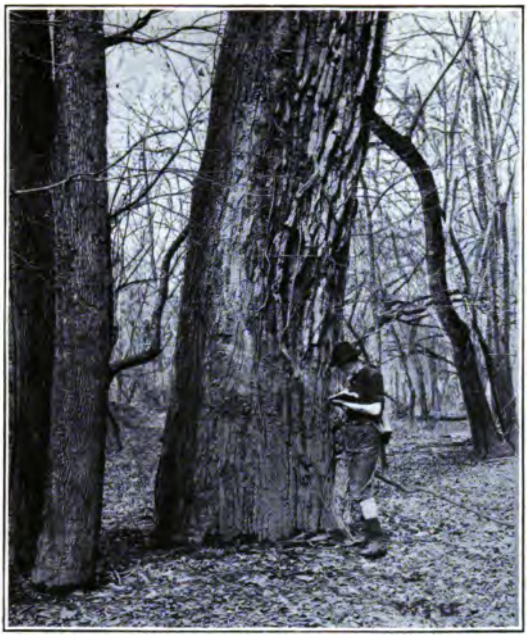


FIG. 1.—A LARGE COTTONWOOD—ONE OF THE ASSOCIATES OF RED GUM ON THE HARDWOOD BOTTOMS—RICHLAND COUNTY, S. C.

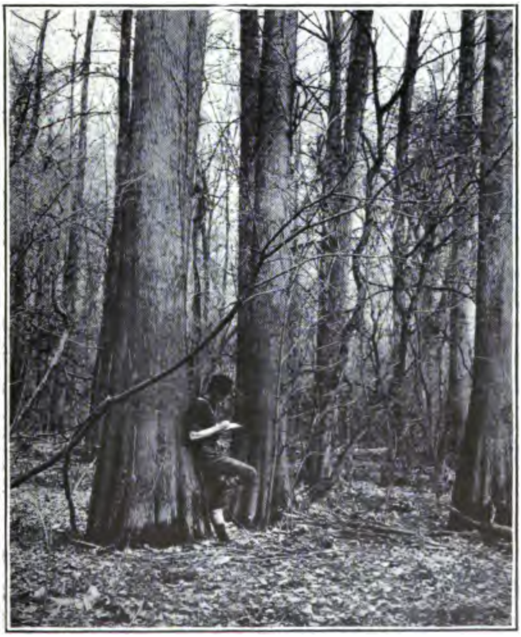


FIG. 2.—A CYPRESS SLOUGH IN THE DRY SEASON, SOUTH CAROLINA.

this purpose, but with the advance in price of these woods a substitute had to be found, and red gum, owing to its cheapness, was experimented with and found to be quite satisfactory. The objection was at first raised that it tended to break in bending, but after much experiment it was found that by steaming it more than cottonwood or elm, the breakage was greatly decreased, and at the present time the percentage is no larger than in these other woods.

The relative price of logs delivered at the mill is $6 to $7 per 1,000 board feet, against $9 to $10 for elm and about $12 for cottonwood. The gum is, therefore, 25 to 50 per cent cheaper than these other hardwoods.

The use of gum in the manufacture of tight barrels, such as are used for oil, molasses, whisky, etc., is now in the experimental stage. Some few barrels have been made, but they have not as yet been introduced on the market. An oil company is erecting at Memphis, Tenn., a factory for the manufacture of such barrels from red gum, which will consume from 3,000,000 to 6,000,000 board feet of lumber per year. In the experimental stage the wood has been found easy to bend, and, being free from knots, it makes a good joint and seems to fill all necessary requirements.

During the last six years lumber dealers have been introducing red gum flooring on the market. They advertise it as lasting longer than any other wood now used in flooring, as having a smoother surface, and as being easier to handle. They claim that they thoroughly dry the timber before disposing of it to the trade, and in this manner overcome all objections to it. Some of the statements made in this connection must be accepted with caution, though it is a fact that red gum makes very good flooring. As a floor is seldom exposed to the weather, and as the temperature in a building is practically the same at all times, there is little doubt that the use of red gum flooring will increase in the next few years. The grade of lumber used in flooring is usually common. Estimates made by various dealers in Cincinnati place the amount of gum used for flooring during the year 1903 at about 18,000,000 feet.

A large amount of red gum is put into wagon-box boards, which have a separate grade under the National Hardwood Lumber Association's rules. All of the sapwood that will make wagon-box lumber is cut up for this purpose, because, when thoroughly dried and painted, sapwood is as good as heart. The specifications call for material from 11 to 17 inches in width. Owing to the size of the red gum, the straightness of its grain, and the small number of its knots, a larger percentage of such boards can be cut from it than from any competing species. In this line of work gum is also being introduced as a substitute for yellow poplar and cottonwood, and is cheaper than either. In the St. Louis market yellow poplar wagon-box boards are worth $47 per thousand board feet, cottonwood $37, and red gum $23. The weight of gum and its tendency to warp are objections to its use for this purpose, but its redeeming advantages are its cheapness, the small amount of paint necessary to cover the boards, and the fact that other woods are now often hard to obtain. Greater care in handling will remove many of the objections to its use.

From the years 1900 to 1902 much of the clear heart of the red gum was cut into 3 by 9 inch stock, 16 feet long, to be used for paving blocks, principally in London, England. This was one of the first uses found for the wood. In 1902 the market in London gave way, and as a result a number of mills were left with a lot of 3 by 9 inch stock on their hands. Owing to this large supply they are now trying to introduce gum as a paving-block material in the United States, and several large cities are considering such a use of this wood. The qualities necessary for a good paving block are durability, close grain, and the power of resisting abrasion. These qualities are found in red gum.

The heartwood of the gum is used extensively in the South for fence posts, and, in a limited way, for sills. Where it is carefully selected and well seasoned, red gum is more lasting than red oak or short-leaf pine.

A large amount of gum is now being cut into 2 by 2 inch and other square stock up to as large as 10 by 10 inches, for turning blocks. It takes a beautiful finish, and as the consumers are now carefully seasoning the wood they are overcoming the tendency to check. It has received special attention for this purpose in England and Germany, and many mills in the South are now cutting this dimension stuff for export.

Red gum has been used to some extent for railroad ties, but on account of the difficulty in seasoning them and the fact that the wood checks badly—usually at the places where spikes are driven—it has proved unsatisfactory for this purpose.

Red gum is also used extensively for coffin boards, screen doors, moldings, broom handles, mop handles, wheelbarrows, brush backs, and pulley facing. It is especially suitable for the last, because it is an easy wood to hold with glue and requires little to make a joint.

PROPERTIES OF THE WOOD.

Many of the purposes for which red gum is or may be used have just been mentioned. Its mechanical properties are discussed in the second part of this bulletin. The intrinsic qualities which make it fit or unfit for any purpose may be summed up as follows: The wood is about as strong and as stiff as chestnut, or a little weaker than shortleaf pine; it splits easily and is quite brash; it is less tough than cottonwood and splinters less; it is about as hard as yellow poplar and can be worked with tools almost as easily; it has a moderately fine grain, is denser than cottonwood, and has a large proportion of sapwood; the sapwood decays rapidly when exposed to the weather, but the heartwood is quite durable even in the ground. The green wood contains much water and consequently is heavy and difficult to float, but when dry it is as light as basswood, or about 15 per cent heavier than yellow poplar or cottonwood. The great amount of water in the green wood, particularly in the sap, makes it difficult to season by ordinary methods without warping and twisting. This fault can be overcome, however, by special treatment. The color of the heartwood is a rich reddish brown; that of the sapwood cream white. It is tasteless and odorless, and, when once seasoned, swells and shrinks little unless exposed to the weather. Its structure is so uniform that it can be stained, painted, or glued without absorbing much of the material.

It is evident that red gum is not strong enough for construction timbers, and that its greater weight is a disadvantage when compared with yellow poplar and cottonwood. These points are of little importance, however; other woods may still be had where strength is required, and the lower price of red gum easily offsets the increased cost of transportation entailed by its heavier weight.

Thus the chief objection to it is its strong tendency to warp and twist. There is little doubt that this quality has been magnified by mill men and users, yet that it can be overcome is as true as that it does exist. It is entirely a question of proper handling. (See Seasoning, p. 24.)

PRICES OF RED GUM LUMBER.

The present status of red gum is well shown by comparison of its market price with the prices of the woods with which it competes. This is made in Table I.

TABLE I.—*Prices of red gum and competing woods in St. Louis per 1,000 feet B. M.*

[From St. Louis Lumberman, May 1, 1905, and Southern Lumberman, February 10, 1905.]

Grade.	Red gum.	Yellow poplar.	Cottonwood.	Yellow pine.	Cypress.
Firsts and seconds	$27.00	$43.00	$27.00	$32.00	$41.25
No. 1 common	14.50	29.00	22.00	20.75	36.25
No. 2 common	11.00	20.00	22.00	18.25	33.00
Box boards	8.50	16.00	14.50	14.00	25.75
Wagon-box boards	23.00	47.00	37.00	....	....

The railroad companies have allowed a lower freight rate on red gum from southern shipping points than on most of the other hardwoods, because of its low value and their desire to have this wood introduced into the northern markets. This has undoubtedly been of great assistance in establishing its use in the North.

MILLING.

The sawmills used in cutting red gum are the same as those used in cutting the other hardwoods. They are usually equipped with one large 10 to 14 inch band saw, and have a capacity of between 25,000 and 50,000 board feet per day. The circular saw is practically disappearing in this line of work, although a few are still found, chiefly in the smaller mills.

The logs are usually stored at the mill in a bayou. They are practically always plain sawed, although the general impression is that by quarter-sawing gum the tendency of the boards to warp and twist will, in a large measure, be overcome. The prices obtainable at present for gum, however, do not warrant the additional expense of quarter-sawing.

From the fact that the mills are so widely scattered over the country and that each conforms in a measure to local usage, there is, of course, a great diversity in the grades of lumber sawed. The usual grades and the average per cent of each cut are as follows:

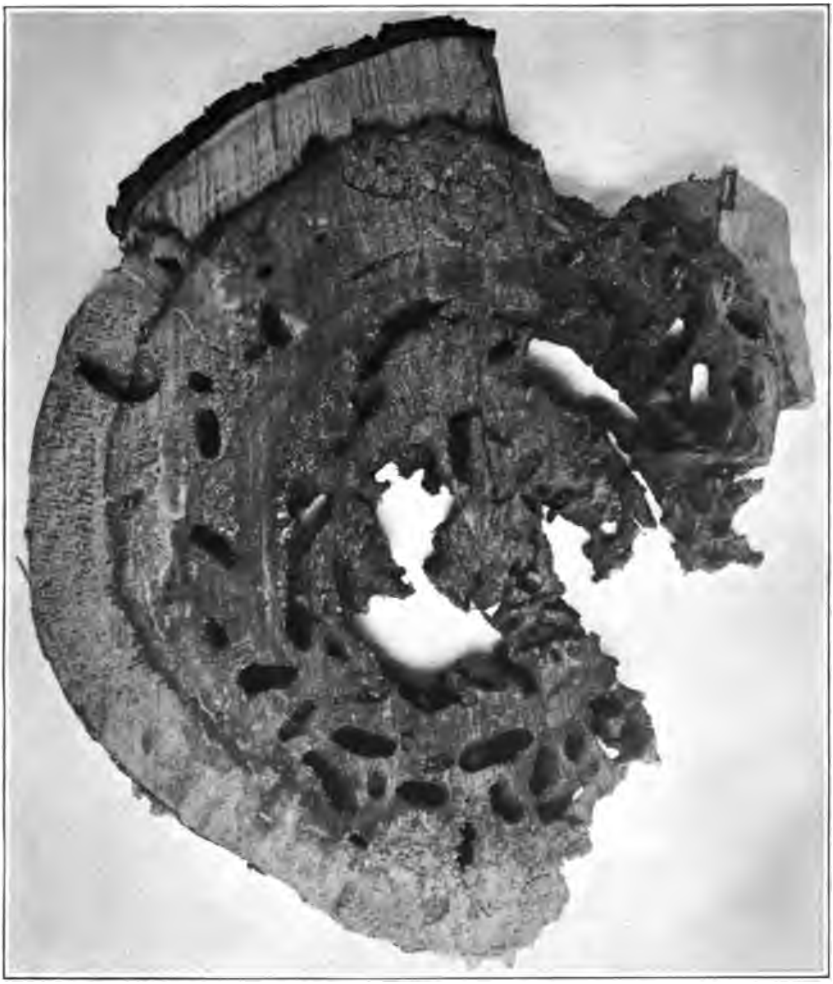
Grade.	Per cent of cut.	
	Mississippi States.	Atlantic States.
First and second clear, heart	25	8
Common, red or heart	15	17
First and second clear, sap	25	32
Common, sap	20	27
Cull	15	16

The red gum probably has as little cull cut from the log as any of the other hardwoods, with the exception of yellow poplar and the tupelo gum cut in the Mobile district.

Red gum logs can be brought from the river, run through the saw, and trimmed and edged for from $2.50 to $3 per thousand board feet. Grading and piling usually cost, in the large mills, from 70 to 80 cents per thousand. This, added to the price paid for the logs delivered in the pond, which is from $6 to $7 per thousand board feet, and with proper allowance for the capital invested in the plant and the necessary wages of superintendents, inspectors, etc., would make the timber placed in the yards cost from $12 to $14 per thousand board feet.

SEASONING.

The principal difficulty found in introducing red gum on the market is the indisputable fact that it is very liable to warp and twist. In this respect, with the possible exception of elm, it is the poorest hardwood now on the timber market. This difficulty is thoroughly recognized, however, by both the sawmill men and the manufacturers, and they are finding means to overcome it.



SECTION FROM THE BUTT OF A RED GUM GROWN IN MISSOURI, SHOWING DECAY FOLLOWING INJURY BY FIRE AND INSECTS.

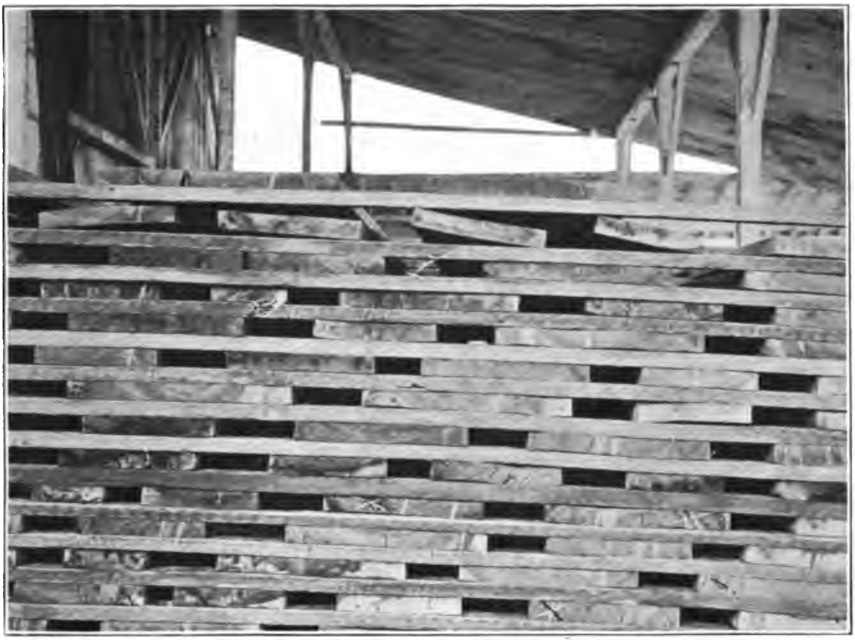


FIG. 1.—ONE-INCH RED GUM BOARDS, KILN-DRIED, SHOWING PROPORTION OF WARP AND TWIST.

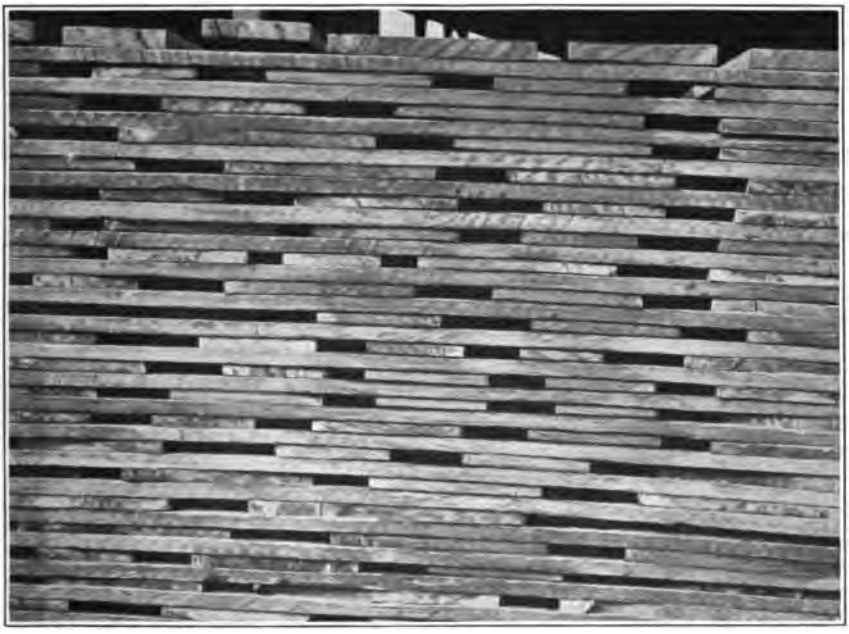


FIG. 2.—RED GUM BOARDS, FIVE-EIGHTHS INCH SAPWOOD SELECTS AND NO. 1 COMMON, VERY FREE FROM CHECK.

In the early stages of milling red gum, oak, ash, and hickory formed the principal cuts of the mills, and very little attention was paid to different methods of drying. Few dry-kilns were at first used. It was soon found, however, that gum could not be dried with other hardwoods, and, as a result, the pioneer millmen of the South gave it the reputation of being impossible to handle in the yard, or to use either as a construction timber or for any line of manufacture. Owing to this belief, very little red gum was cut for a great many years. With the appearance of yellow poplar and cottonwood on the market, improved methods of handling were adopted. Finally, a few years ago, the growing scarcity of woods used for interior finishing, furniture, boxes, and other purposes where a clear, light-colored wood is required, caused red gum to be again cut. But this time more attention was paid to drying and handling it, and the sawmill men gave special attention to piling the lumber.

The boards should be piled in the yard so as to have plenty of air space between the tiers and one-half foot beneath them, in order to permit a free circulation of air under and through the piles. In the first ten or fifteen layers the boards should be laid from 6 to 8 inches apart, and afterwards from 2 to 3 inches apart to the top of the pile. The piles should not be over 6 feet wide. The strips, or stickers, which in other hardwoods are placed 4 or 5 feet apart between the tiers, should with gum be placed from 1½ to 2 feet apart. To prevent the staining which will otherwise occur where the stickers are laid, they must be thoroughly dry, and preferably of oak or the heartwood of gum. Staining is much more apt to occur in the sapwood than it is in the red or heartwood of gum. It is very objectionable, because in nearly all cases the discoloration of the board causes the inspector to refuse it in grading. The use of absolutely dry stickers easily overcomes this difficulty.

By using these methods in piling their lumber, and then allowing it to stand in the yard from three to six months, the mills have been able to furnish fairly straight, clear boards. (Pl. VI.) This extra attention has, of course, increased the price of gum. It would not pay to handle it if its uses had not multiplied.

Gum boards are also successfully dried in the kiln, but pieces over 2 inches thick are apt to case-harden, and consequently to season on the outside only. The sapwood of gum should be kiln-dried rather than air-dried, as it is more liable to stain if put in the yard. On account of the tendency to stain if piled when green, and the difficulty of kiln-drying thick pieces, it is usually advisable to saw green sapwood into boards only. In kiln-drying, the same attention is paid to piling as is paid in the yard. Whenever possible, cypress is laid on top of the cars before they go into the kiln, to prevent the top boards from warping. Some mills, in which no cypress is sawed, place a pressure on the top boards.

In kiln-drying, two different methods are commonly used. The first one employs an air-blast kiln, in which the timber is allowed to remain for from 19 to 22 days. For the first day a temperature of approximately 70° F. is maintained, after which the heat is gradually increased until, on the last day, it reaches 150° or 160° F. The other process is steam kilning, which consists in thoroughly soaking the timber in live steam for about 72 hours and then drying it by means of steam radiation for from 72 to 144 hours, according to the condition of the timber. The best results are obtained from any method of seasoning when the logs are kept in water for six weeks or more before sawing. This greatly reduces the tendency to stain.

The small mills throughout the country carelessly air-dry all their output, both sap and heart wood, and in this way turn out a poor grade of gum lumber that is apt to warp and twist, and has done much to give the wood its bad reputation.

Like most other hardwoods, red gum absorbs moisture and swells when exposed to dampness and shrinks again when it gives up its moisture. Thus a seasoned piece may warp and twist as if green, when it is not protected from the weather.

Furniture factories, after receiving the lumber from the sawmills, base their plan of manufacture on the assumption that its drying has received very little attention in the mill yard. A large part of their product is cut into $\frac{3}{16}$-inch and $\frac{1}{4}$-inch veneers, which it is essential to have thoroughly dry before they are covered with paint or varnish. Several processes of drying this veneer have been patented, practically all of which are based on the same principle. Two large iron plates clamped on the wood hold it securely in one position, while steam and hot air are alternately passed through until the fibers are cleared of their sap. The wood is then thoroughly dried. After the veneers are taken from the drier they are glued together, given a body varnish, and placed in furniture.

LUMBERING, MANUFACTURE, AND USES OF TUPELO GUM.

The close similarity which exists between red and tupelo gum, in methods of lumbering and manufacture, and in the obstacles to be overcome in handling, together with the fact that tupelo is often cut along with red gum and marketed with the sapwood of the latter, makes it not out of place to give brief consideration to this timber.

Tupelo gum, found in more or less large quantities throughout the range of the red gum, is cut to some extent from Virginia to the Gulf and westward to Arkansas. Its best growth, however, is in the Gulf States, and as a commercial timber tree it has as yet reached great importance only in a single district in Alabama. Throughout much of its range it is cut only when found with red gum. In the vicinity of

Mobile, however, in the bottom lands of the Tombigbee, Tensas, and Mobile rivers, it has received special recognition. In this locality there are mills which cut this wood only. Estimates based on figures given by the mill owners in Mobile indicate that there are about 200,000,000 board feet of tupelo now standing in this district. The mills are at present cutting from 15,000,000 to 20,000,000 board feet per year, which would indicate that the tupelo gum in this locality will be almost exhausted in a few years.

There is no distinction in color between the sap and heart wood of tupelo, so the uses of the two are the same. Tupelo is chiefly sold on the market under the name of bay poplar, a name which it acquired from the fact that it was substituted for a grade of yellow poplar found along the Atlantic coast in the vicinity of Baltimore. The poplar in that locality nearing exhaustion, the dealers sent cruisers to Alabama to cut a few tupelo trees, and had the timber introduced on the market under the name of bay poplar. It was found to be measurably satisfactory, and is now used to a considerable extent. No objection was made to calling the lumber from this tree poplar, and since its increased use the name has never been changed. In the furniture trade it is sometimes also called Circassian walnut, and a few manufacturers call the wood nyssa, which is its correct botanical name and is rather preferable to bay poplar.

LOGGING.

In logging tupelo the unusual weight of the green timber gives rise to the same difficulty that is encountered in the case of red gum. The method first employed was to cut the trees in the fall and allow them to lie in the woods until the high water set in late in the winter, when the logs were floated along roads cut through the forest to the river, and thence rafted or floated down to the mills. In other cases girdling was resorted to. This was done in the summer, usually starting the first of July and continuing to within ninety days of high water.

As the demand for this timber increased, however, it became impossible to float out the necessary amount during the short period of high water. Consequently within the last two or three years a number of pull boats—steam skidders on scows—have been put in operation. These are moved from place to place along the streams and drag the logs directly from the forest to the river. In this way logs can be skidded throughout the year.

QUALITIES AND USES.

Tupelo gum possesses about the same weight and strength as red gum, but it is much tougher and is very perishable when exposed. Both sapwood and heart are cream white in color; hence the lumber has an unusually clean appearance. Owing to the difficulty of seasoning large pieces, the logs are usually cut into boards 1 inch or less in thickness. These boards are used for furniture drawers and backs, for panelwork and inside finish, and, above all, for boxes. Few woods are at the same time so light, strong, and cheap—the three qualities needed in box material. The wood is also used largely for moldings, for wagon boxes, etc., but it is not durable enough for flooring. Like red gum, tupelo is easily glued, painted, or varnished, and absorbs little of the material. In this respect it is better than yellow poplar and much better than cottonwood.

METHODS OF HANDLING.

In piling the lumber it is necessary to have the cross strips between the tiers laid not less than four to a 16-foot length. Tupelo gum boards require from five to eight months to become air dry. They should be piled so that they will receive plenty of ventilation, and staining be prevented. This staining is in a large measure overcome if the tree is girdled and given plenty of time to dry before it is felled.

In common with red gum, tupelo has suffered from the fact that it was not thoroughly dried when used. Consequently the manufacturers were not able to handle it in their work with the ease that they did cottonwood and yellow poplar. Now, however, the wood has become thoroughly introduced on the market and is increasing rapidly in value.

Owing to its limited supply, the grading of tupelo gum has not received special recognition by the hardwood associations, but, since it often replaces poplar and cottonwood, it is now frequently graded under a combination of the grading of these two woods. No discrimination is made between heart and sap wood, because of their resemblance in color and the fact that they are both used for the same purposes. The grade of commons permits of any amount of stain, and knots are also allowed, but as this lumber is practically free from knots, the question of their presence is of little importance in the inspection.

The price of tupelo gum increased from $9 per thousand board feet, log run, at the time of its introduction on the market in 1900, to $16 per thousand board feet in 1903. At present (1905) all the mills handling this wood have orders for their entire output as fast as it is dried.

RATE OF GROWTH OF RED GUM.

The rate of growth of red gum differs considerably in the two localities examined. In South Carolina the growth in both height and diameter, as shown in Tables II and III, is more rapid during youth than in Missouri, and from the fact that the clear length is greater for trees of the same diameter, the merchantable volume in board feet is slightly higher. On the other hand, the trees in Missouri reach a greater final diameter and an older age than those along the coast, and the percentage of sapwood is smaller.

The reasons for this difference in the rate of growth in the two localities are to be found in the differences in soil and climatic conditions. The bottoms along the Atlantic coast are more subject to floods than those in the Mississippi Valley States, and the humidity is greater. Swamp conditions prevail more widely also, and for this reason the forest growth is more rapid, and the trees contain a larger percentage of sapwood. Their more rapid development during youth brings about an earlier culmination of growth. The climate of the Mississippi Valley seems to favor a slower but more steady development, and the gum here reaches its largest dimensions.

The following table shows, on a basis of diameter breasthigh, the total height and clear length of red gum in the two localities. The table is based on the measurement of 1,555 trees in South Carolina and 1,781 trees in Missouri.

TABLE II.—*Total height and clear length of red gum.*

Diameter breast-high.	Total height.		Clear length.		Diameter breast-high.	Total height.		Clear length.	
	South Carolina.	Missouri.	South Carolina.	Missouri.		South Carolina.	Missouri.	South Carolina.	Missouri.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	15	12	6	3	19	110	99	58	44
2	25	19	10	4	20	112	100	58	46
3	35	25	14	6	21	114	102	58	47
4	43	31	18	8	22	115	103	58	49
5	50	37	23	10	23	117	105	58	51
6	58	43	28	12	24	118	107	58	52
7	64	49	34	15	25	119	109	58	53
8	70	56	39	18	26	120	111	58	53
9	76	62	44	21	27	120	112	58	54
10	81	69	48	24	28	121	113	58	54
11	86	75	51	28	29	121	114	58	54
12	91	80	54	32	30	121	115	58	54
13	95	85	56	35	31	121	116	58	54
14	99	89	57	37	32	122	117	58	55
15	102	92	57	39	33	122	118	58	55
16	104	95	58	40	34	122	119	58	56
17	106	96	58	42	35	122	120	58	56
18	108	98	58	43	36	122	121	58	57

It will be seen from this table that trees of the same diameter are slightly taller in South Carolina than in Missouri. This difference is greatest when the diameter is about 8 inches. The mature trees, however, are of about the same height at a given diameter in the two localities.

The greater clear length of trees in South Carolina is probably due to the greater energy of growth, combined with the greater density of the young stands. There the large number of rapid-growing cottonwood, ash, and gum tends to produce stands of clear, straight timber. It is noteworthy, however, that the maximum clear length is 58 feet. This undoubtedly is due to the habit of the tree to fork when it has reached a definite stage in its development. (See page 12.) Where the height growth is rapid, as in South Carolina, that stage is reached when the tree is 16 inches in diameter. In the slower-growing Missouri forests the forking does not occur until the trees are much larger and older.

The following table gives the age of red gum in South Carolina and Missouri, on a basis of diameter breasthigh. From this table can be learned not only the number of years required for trees to grow to a given size, but also, by subtraction, how long it will take trees of any size to reach any other specified size.

Table III.—*Age of red gum trees.*

Diameter breast-high.	Age.		Diameter breast-high.	Age.	
	South Carolina.	Missouri.		South Carolina.	Missouri.
Inches.	*Years.*	*Years.*	*Inches.*	*Years.*	*Years.*
1	6	9	16	55	74
2	8	14	17	60	78
3	10	19	18	65	82
4	12	24	19	70	86
5	14	28	20	75	91
6	17	32	21	81	96
7	20	36	22	87	102
8	23	41	23	93	108
9	26	45	24	100	116
10	30	49	25	107	124
11	34	54	26	114	134
12	38	58	27	121	146
13	42	62	28	128	163
14	46	66	29	135	182
15	50	70	30	142	210

VOLUME OF RED GUM.

The Doyle-Scribner log rule has been used in calculating all volumes in this report. The trees have been scaled, where possible, down to a diameter of 10 inches in the tops, although on large trees the diameter to which logs can be cut in the top depends entirely on the clear length, as large trees generally have a considerably greater diameter than this where the stems begin to branch.

The data for Table IV, which gives the contents of standing trees in board feet, were obtained from the scaling of trees as cut into actual log lengths. In order to obtain comparable figures for the two localities, however, logs were scaled, where the clear lengths would permit it, down to 10 inches in the tops. The difference between the volumes of the trees in South Carolina and in Missouri is largely due to the greater clear length in the former locality. The table is based on the measurements of 849 trees in South Carolina and 801 trees in Missouri.

TABLE IV.—*Merchantable contents of red gum trees.*

Diameter breast-high.	Volume.		Diameter breast-high.	Volume.	
	South Carolina.	Missouri.		South Carolina.	Missouri.
Inches.	*Bd. ft.*	*Bd. ft.*	*Inches.*	*Bd. ft.*	*Bd. ft.*
13	20	15	31	1,040	975
14	65	45	32	1,125	1,055
15	110	80	33	1,210	1,145
16	155	110	34	1,300	1,245
17	200	145	35	1,400	1,350
18	250	180	36	1,505	1,465
19	300	215	37	1,620	1,575
20	350	250	38	1,735	1,675
21	405	295	39	1,850	1,760
22	460	340	40	1,960	1,835
23	515	400	41	2,055	1,900
24	570	465	42	2,155	1,955
25	625	535	43	2,250	2,010
26	685	610	44	2,340	2,055
27	745	685	45	2,425	2,115
28	805	760	46	2,510	2,165
29	875	840	47	2,590	2,215
30	955	900	48	2,670	2,265

The following table is constructed to show the amount and percentage of sapwood of red gum in South Carolina and in Missouri, as indicated by linear measurements on a cross section at the stump. It gives, for successive breasthigh diameter classes, the diameter of the stump inside the bark, the width of the sapwood, and the percentage of the cross-section area that is sapwood. It will be seen that red gum in South Carolina contains a much larger percentage of sapwood than that in Missouri. This is accounted for by the faster rate of growth in the former locality.

TABLE V.—*Sapwood in red gum.*

Diameter breast-high.	South Carolina.			Missouri.		
	Diameter inside bark at stump.	Sapwood at stump.	Percentage of cross section area that is sapwood.	Diameter inside bark at stump.	Sapwood at stump.	Percentage of cross section area that is sapwood.
Inches.	*Inches.*	*Inches.*	*Per cent.*	*Inches.*	*Inches.*	*Per cent.*
15	15.9	9.5	84	15.4	5.7	60
16	16.9	10.2	84	16.4	5.9	59
17	17.9	10.9	85	17.5	6.0	57
18	19.0	11.6	85	18.5	6.1	55
19	20.0	12.2	85	19.5	6.2	53
20	21.1	12.9	85	20.6	6.3	52
21	22.1	13.5	85	21.6	6.4	50
22	23.2	14.1	85	22.6	6.5	49
23	24.2	14.6	84	23.7	6.6	48
24	25.2	15.1	84	24.7	6.7	47
25	26.3	15.5	83	25.8	6.8	46
26	27.3	15.9	83	26.8	6.9	45
27	28.3	16.3	82	27.9	7.0	44
28	29.3	16.6	81	28.9	7.1	43
29	30.4	16.9	80	29.9	7.1	42
30	31.4	17.2	80	31.0	7.2	41
31	32.5	17.4	78	32.0	7.3	40
32	33.5	17.6	77	32.1	7.4	40
33	34.6	17.9	77	34.1	7.5	39
34	35.6	18.1	76	35.1	7.5	38
35	36.6	18.3	75	36.1	7.6	38
36	37.7	18.4	74	37.2	7.7	37
37	38.7	18.6	73	38.2	7.7	36
38	39.7	18.8	72	39.2	7.8	36
39	40.7	18.9	71	40.2	7.9	35
40	41.7	19.0	70	41.2	7.9	35

Since red gum does not occur in pure stands, but always grows mixed with a variety of other merchantable species, it has been impossible, in the absence of volume tables for these other species, to construct any yield tables showing the total yield in board feet per acre of the forest on hardwood bottomland. Sample plots and valuation surveys were taken, however, in mature virgin forest and in stands of various ages, in order to show the usual mixture of species in these forests and the stand per acre of red gum alone. The stand tables given for Missouri and South Carolina hardwood bottoms may be considered as typical of these two sections, and are based on a large number of valuation surveys and sample plots. They are not, however, of general application in their respective regions, as are the volume tables, since the mixture of species varies greatly over very small areas, and stand tables must be made for each locality where they are required.

On the sample areas all trees 1 inch and over were calipered at 4½ feet from the ground, and the volume of trees over 13 inches in diameter breasthigh was calculated from Table IV above. All sound trees were scaled, and a cull of 20 per cent was deducted for crooked, scrubby, or otherwise defective trees. The number of acres actually measured is given at the head of each table. It should be remembered that these acres were all carefully selected, so as to obtain average conditions in respect to both the size and the number of the trees.

Tables VI and VII show the average stand for virgin forest on hardwood bottomland in South Carolina and in Missouri. Table VIII gives the stand for some good second-growth forest in South Carolina. The percentage of red gum is here rather high. This forest is about 80 years old.

TABLE VI.—*Virgin hardwood bottomland, South Carolina.*

NUMBER OF TREES PER ACRE.

[Average of 37 acres.]

Diameter breasthigh.	Red gum.	Cottonwood.	White ash.	Red oak.	Sycamore.	Maple.	Elm.	Hackberry.	Other species.	All species.
Inches.										
1	....	0.71	0.71	....	1.00	....	0.71	....	29.71	32.84
2	....	.14	2.00	....	.14	1.00	2.71	0.57	17.55	24.11
3	....	.14	1.71	....	.43	1.57	5.00	.27	5.81	14.93
4	2.37	....	4.37	0.03	.27	1.97	6.93	.97	4.40	21.31
5	3.00	....	4.30	.20	.37	2.27	7.47	.97	3.06	21.64
6	3.37	....	4.37	.07	.33	3.03	5.37	.73	1.79	19.06
7	2.87	....	2.80	.07	.23	2.20	4.07	.63	.90	13.77
8	2.63	.03	2.20	.10	.33	1.83	1.97	.33	.67	10.09
9	2.53	.03	1.53	.13	.20	1.13	1.20	.23	.33	7.31
10	2.87	.07	1.87	.10	.10	1.00	.87	.17	.33	7.38
11	2.67	.07	1.90	....	.07	.57	1.00	.07	.16	6.51
12	2.80	.10	2.07	.07	.13	.77	.53	.17	.13	6.77
13	1.83	.10	1.20	.03	.10	.50	.33	.17	.24	4.50
14	2.43	.27	.83	.07	.13	.33	.20	.03	.03	4.32
15	1.53	.23	1.33	.07	.13	.27	.30	....	.03	3.89
16	2.13	.23	1.20	.07	.23	.30	.17	.03	.03	4.39
17	2.00	.20	.67	.03	.20	.23	.17	.07	.16	3.73
18	1.77	.40	.57	.03	.07	.13	.13	.03	.06	3.19
19	1.27	.30	.47	.10	....	.17	.10	....	.03	2.44
20	1.00	.33	.40	.07	.20	.03	.13	....	....	2.16
21	.93	.23	.57	.10	.10	.07	.07	....	....	2.07
22	1.13	.33	.33	.07	.07	.03	.03	....	....	1.99
23	.80	.30	.13	.03	.03	.07	....	....	....	1.36
24	.43	.13	.07	.07	.03	.03	....	....	....	.76
25	.17	.30	.13	.07	.03	.10	....	....	....	.80
26	.50	.27	.03	....	.07	....	....	....	....	.87
27	.30	.13	.07	.07	.03	.03	....	....	....	.63
28	.23	.20	....	.10	....	....	....	....	....	.53
29	.13	.23	.13	.03	....	....	....	....	....	.52
30	.17	.27	.13	.03	.03	....	....	....	....	.63
31	.03	.17	....	....	....	.03	....	....	....	.23
32	....	.20	....	.07	....	....	....	.07	....	.34
33	.03	.07	....	.10	.03	....	....	.13	....	.36
34	....	.03	....	.07	....	....	....	.13	....	.23

TABLE VI.—*Virgin hardwood bottomland, South Carolina*—Continued.

Diameter breasthigh.	Red gum.	Cotton-wood.	White ash.	Red oak.	Syca-more.	Maple.	Elm.	Hack-berry.	Other species.	All spe-cies.
Inches.										
35	0.03	0.07	0.03	0.17	....	....	....	....	....	0.30
36	....	.03	....	.10	....	....	....	0.03	....	.16
37	....	.03	....	....	....	....	....	....	....	.03
38	....	.03	....	.03	0.07	....	....	....	....	.13
39	....	....	....	.07	.03	....	....	.03	....	.13
40	....	....	....	.07	....	....	....	.03	....	.10
41	....	....	....	....	....	....	....	....	....	....
42	....	....	....	.03	.03	....	....	....	....	.06
48	....	....	....	....	....	....	....	....	0.03	.03
49	....	....	....	.03	....	....	....	....	....	.03
50	....	.03	....	....	....	....	....	....	....	.03
Total	43.95	6.40	38.12	2.55	5.21	19.66	39.46	5.86	65.45	226.66
Per cent	19.39	2.82	16.82	1.12	2.30	8.67	17.41	2.59	28.88	100.00

TREES 13 INCHES AND OVER IN DIAMETER BREASTHIGH.

Total	18.84	5.11	8.29	1.78	1.61	2.32	1.63	0.75	0.61	40.94
Per cent	46.02	12.48	20.25	4.35	3.93	5.67	3.98	1.83	1.49	100.00

Yield of red gum 13 inches and over in diameter breasthigh, allowing 20 per cent cull, 4,050 board feet per acre.

TABLE VII.—*Virgin hardwood bottomland, Missouri.*

NUMBER OF TREES PER ACRE.

[Average of 76 acres.]

Diameter breasthigh.	Red gum.	White oak.	Black oak.	White ash.	Red maple.	Elm.	Black gum.	Shag-bark.	Other species.	All spe-cies.
Inches.										
1	1.28	1.47	0.97	13.47	0.61	0.11	0.12	0.05	16.47	34.55
2	.54	.91	.33	4.43	.68	.43	.59	.03	11.64	19.58
3	.36	.70	.17	2.36	.86	1.39	1.14	.04	4.42	11.44
4	.28	.82	.17	1.91	1.22	2.33	1.30	.04	2.86	10.93
5	.45	.80	.08	1.95	1.28	2.29	1.17	.01	3.01	11.04
6	.45	.82	.13	1.89	1.36	2.25	1.53	.04	2.37	10.84
7	.32	.83	.07	1.47	1.37	1.75	1.72	.05	1.54	9.12
8	.23	.70	.05	1.32	1.13	1.54	1.20	.09	1.23	7.49
9	.38	.85	.16	1.42	1.13	1.70	1.45	.05	1.24	8.38
10	.37	.54	.09	.95	1.14	1.03	1.13	....	.59	5.84
11	.36	.54	.17	.96	1.05	1.36	.92	.04	.52	5.92
12	.38	.66	.22	.82	1.32	.91	.95	.07	.39	5.72
13	.33	.46	.13	.54	1.16	.85	.86	.04	.29	4.66
14	.42	.53	.16	.50	.98	.79	.66	.05	.25	4.34
15	.41	.62	.16	.42	1.07	.75	.55	.05	.37	4.40
16	.48	.43	.14	.37	.95	.43	.38	.01	.10	3.29
17	.39	.38	.16	.13	.80	.72	.29	.04	.15	3.06
18	.43	.29	.22	.14	.66	.47	.28	.04	.13	2.66
19	.54	.25	.16	.05	.70	.41	.22	.01	.07	2.41
20	.47	.36	.17	.01	.68	.34	.13	.03	.04	2.23
21	.29	.21	.20	.01	.68	.38	.20	.01	.04	2.02

TABLE VII.—*Virgin hardwood bottomland, Missouri*—Continued.

Diameter breasthigh.	Red gum.	White oak.	Black oak.	White ash.	Red maple.	Elm.	Black gum.	Shagbark.	Other species.	All species.
Inches.										
22	0.43	0.28	0.08	....	0.57	0.36	0.20	0.01	0.01	1.94
23	.43	.14	.09	0.03	.32	.11	.18	....	.03	1.33
24	.64	.11	.20	.01	.48	.17	.16	.01	.01	1.79
25	.41	.23	.21	....	.29	.14	.07	....	....	1.35
26	.53	.13	.13	.01	.26	.11	.05	.03	....	1.25
27	.50	.11	.17	....	.21	.09	.12	.03	.03	1.26
28	.55	.07	.11	....	.17	.04	.03	....	.03	1.00
29	.47	.05	.14	....	.14	.04	.08	....	....	.92
30	.54	.08	.05	....	.13	.03	....	....	....	.83
31	.53	.07	.03	....	.07	.04	.01	....	....	.75
32	.23	.04	.08	....	.05	....	.01	....	....	.41
33	.32	.04	.08	....	.07	.01	....	.01	....	.53
34	.36	.03	.03	....	.05	.01	.04	....	....	.52
35	.34	.04	.01	....	.04	.05	.03	....	....	.51
36	.28	.01	.03	....	....	....	....	....	....	.32
37	.17	.01	.04	....	.01	....	.01	....	....	.24
38	.20	.03	.01	....	....	.01	....	....	....	.25
39	.04	....	.01	....	.01	....	....	....	....	.06
40	.08	....	.03	....	....	....	....	....	....	.11
41	.05	....	....	....	....	....	....	....	....	.05
42	.03	....	....	....	....	....	....	....	....	.03
43	.04	....	....	....	....	....	....	....	....	.04
44	....	....	....	....	....	....	....	....	....	....
45	.01	....	....	....	....	....	....	....	....	.01
46	.01	....	.01	....	....	....	....	....	....	.02
47	....	....	....	....	....	....	....	....	....	....
48	.03	....	....	....	.01	....	....	....	....	.04
49	.01	....	....	....	....	....	....	....	....	.01
Total	16.39	14.64	5.65	35.17	23.71	23.44	17.78	.88	47.83	185.49
Per cent	8.84	7.89	3.05	18.96	12.78	12.64	9.58	.47	25.79	100.00

TREES 13 INCHES AND OVER IN DIAMETER BREASTHIGH.

	Red gum.	White oak.	Black oak.	White ash.	Red maple.	Elm.	Black gum.	Shagbark.	Other species.	All species.
Total	10.99	5.00	3.04	2.22	10.56	6.35	4.56	0.37	1.55	44.64
Per cent	24.62	11.20	6.81	4.97	23.66	14.22	10.22	.83	3.47	100.00

Yield of red gum 13 inches and over in diameter breasthigh, allowing 20 per cent cull, 5,575 board feet per acre.

TABLE VIII.—*Second-growth hardwood bottomland, South Carolina.*

NUMBER OF TREES PER ACRE.

[Average of 3 acres.]

Diameter breasthigh.	Red gum.	White ash.	Cottonwood.	Sycamore.	Elm.	Red oak.	Other species.	All species.
Inches.								
1	0.33	31.67	74.67	....	3.00	....	7.00	116.67
2	.33	2.00	40.00	0.67	13.33	....	18.00	74.33
3	.33	2.00	2.33	....	6.67	....	10.68	22.01
4	.33	1.67	1.00	....	7.67	....	4.33	15.00
5	1.67	....	.33	....	1.67	0.33	1.67	5.67

TABLE VIII.—*Second-growth hardwood bottomland, South Carolina*—Continued.

Diameter breasthigh.	Red gum.	White ash.	Cotton-wood.	Syca-more.	Elm.	Red oak.	Other species.	All spe-cies.
Inches.								
6	1.33	0.33	....	....	3.67	....	0.99	6.32
7	4.00	....	....	....	.67	....	....	4.67
8	3.00	....	....	....	.67	....	....	3.67
9	7.33	....	....	....	.33	0.33	....	7.99
10	9.67	.33	....	0.67	....	....	....	10.67
11	9.67	....	....	....	.33	....	....	10.00
12	13.67	....	....	.33	....	....	....	14.00
13	15.00	....	....	1.00	....	....	....	16.00
14	11.00	.33	....	....	.33	....	....	11.66
15	9.00	....	....	....	....	....	....	9.00
16	7.00	....	....	1.67	.33	....	....	9.00
17	7.67	....	....	.33	....	....	....	8.00
18	9.33	....	....	.67	....	....	....	10.00
19	7.33	....	....	.67	....	....	....	8.00
20	5.67	....	....	....	....	....	....	5.67
21	3.67	....	....	....	....	....	....	3.67
22	3.33	.33	....	.67	....	....	....	4.33
23	1.67	....	....	....	....	....	....	1.67
24	1.00	....	....	....	....	....	....	1.00
25	.33	....	....	....	....	....	....	.33
26	....	....	....	....	....	....	....	....
28	....	....	....	....	....	.33	....	.33
29	.33	....	....	....	....	....	....	....
35	....	....	....	....	....	.33	....	.33
Total	133.99	38.66	118.33	6.68	38.67	1.32	42.67	380.32
Per cent	35.23	10.16	31.11	1.76	10.17	.35	11.22	100.00

TREES 13 INCHES AND OVER IN DIAMETER BREASTHIGH.

	Red gum.	White ash.	Cotton-wood.	Syca-more.	Elm.	Red oak.	Other species.	All spe-cies.
Total	82.33	0.66	....	5.01	0.66	0.66	....	89.32
Per cent	92.17	.74	....	5.61	.74	.74	....	100.00

Yield of red gum 13 inches and over in diameter breasthigh, allowing 20 per cent cull, 12,870 board feet per acre.

Until the preparation of volume tables for ash, cottonwood, and the oaks on hardwood bottomland has been completed, it will be impossible to calculate the total yield and value. Nor is it possible to calculate the financial return obtainable under forest management, since the red gum forms but a small part of these forests and is never cut by itself. Consequently only tentative suggestions for a system of forest management for hardwood bottom forests can be made at the present time.

FOREST MANAGEMENT.

Conservative management for the forests of the hardwood bottomlands of the South can not be outlined in detail until complete studies have been made of the trees composing these forests. Red gum was studied first because of its comparative newness on the market, and because its qualities as a timber tree are not generally understood. During the past winter similar studies of the other important swamp hardwoods, cottonwood, ash, and various oaks have been made. Upon these studies it will be possible to base definite recommendations for the best silvicultural and business management of the southern hardwood swamp forests. In the present bulletin the market standing and certain silvicultural characteristics of three species of gum are discussed. A later bulletin will take up more fully the relation which red gum bears to the forest as a whole.

The problem of the future employment of these hardwood bottomlands, and of the utilization of the forests at present on them, is to-day one of the important problems in the South. For the most part they make excellent agricultural land when cleared, and where it is possible to drain or levee them so that the floods can be controlled or averted, they should be used for agriculture after logging. The South is at present developing so rapidly along agricultural and manufacturing lines that all the better class of farming land is needed for settlement.

Forest management, to be successful, must be practiced on true forest lands. While there is much land now under forest which would make excellent farms, it is impossible to use it for this purpose at present, on account of lack of transportation facilities. Ultimately this land will be placed under cultivation. It may not be cleared after the present timber crop has been cut, and a second growth will doubtless come up on much of it, but before the end of a second rotation the demand for such land will probably have increased to a point where it will no longer pay to hold it in forest.

The southern hardwood lands are, therefore, divisible into three classes; the first embracing those forest lands which will be placed under cultivation as soon as cleared; the second, those lands which are good agricultural lands and will ultimately become farming lands, but which, because they are not so readily accessible, will not be cultivated for many years; and the third, the true forest type of hardwood bottoms. On these the soil is perhaps of equal, or of even better quality than the soil on the other classes, but the land can never be placed under cultivation because of the frequency or depth of floods and the impracticability of constructing dikes or levees and of ditching.

The first class—the land which is of present agricultural value—lies chiefly in the Mississippi Valley. Here railroads and transportation facilities are excellent, the river floods are already under control, and the value of the land is rapidly increasing. Such land is now selling at from $10 to $18 per acre, after the merchantable timber has been removed. Here future forest management is out of the question, but practically all the timber has now a very real commercial value, and it should be properly cut and sold. In the past, when the swamp hardwoods were of little importance, the trees were deadened and burned, as the quickest and easiest method of clearing the land. This method is still employed to some extent, especially on young growth. At present, if such timber can not be sold, it will pay to hold the land a few years, until suitable stumpage prices can be obtained. There are few places where it has not already a considerable merchantable value. On this class of land everything that will make a stick of timber should be cut, as the main object is to obtain the greatest possible yield at the first cutting, which will also be the final one; whatever timber is left standing will be destroyed in clearing the land for agriculture.

On the second class of land—that which can not be used for agriculture for many years, but which will ultimately be valuable for this purpose—it is highly important that care should be used in cutting. Whatever timber is left will then have a chance to develop, and many of the smaller trees will become merchantable by the time land values have reached a limit where it will no longer be profitable to keep the forest. Practical forest management, then, will consist in conserving the present young and unmerchantable growth, with very little regard to reproduction or seedlings. Such reproduction, while it is one of the most important things where continuous forest management is contemplated, is of little importance here, since the land will be used for farming before the seedlings can reach maturity. The object in this case is to obtain the greatest yield from the land in two cuttings, perhaps twenty years apart, after which it will no longer be kept in forest.

This object can best be accomplished by cutting conservatively at present, by using the utmost care to preserve and protect the younger trees, and by keeping fires off the land. Cutting to a rough diameter limit, without regard to leaving seed trees, is the most satisfactory method. Owing to the number of species in the forest, the diameter to which the trees are now cut varies considerably. With the exception of ash it hardly pays to take out logs less than 10 inches in diameter at the small end, or 13 inches in diameter breasthigh. Trees under 12 inches breasthigh are seldom taken. The limit should be made 18 inches diameter breasthigh for all species except ash, which can safely be cut to 12 inches. In the absence of detailed measurements of growth for all species, these diameter limits for cutting are as small as can be advised.

In cutting, all possible care should be taken to save the younger trees, and waste should be avoided by utilizing as much of the tree as is possible. Ash should not be used for ties on the rafts. The unmerchantable species—sycamore, mulberry, etc.—should be used for logging-railroad ties, and also for skids and rollways.

On the third class of hardwood bottomlands—those on which agricultural development is precluded because of the danger from floods and the impossibility of controlling the rivers—forest management is particularly advisable. Here, on account of the extremely rich soil, the growth of all the species is remarkably rapid; and danger from fire, the greatest enemy to forest management, is slight.

The object of forest management on this class of hardwood lands is to obtain the greatest possible continued revenue from the forest. To assure this, the land must be kept continuously in forest growth of the best possible species, and be logged over at proper, recurring intervals, so as to provide a steady source of supply for the mill.

In these forests many of the species are now of commercial value; others must wait to be marketable. The proportion of valuable species also varies with the locality.

All the species seed abundantly, and the seedlings will bear considerable shade during early life, though they will not grow under the cover of canebrake and underbrush. During the spring months floods frequently submerge the whole swamp. Another serious drawback to reproduction is the ranging of hogs and goats in the forest. While cattle are frequently allowed to graze in the woods, they do comparatively little harm to the young growth and none whatever to the seeds, but hogs eat the mast and seeds of every species, particularly of the oaks, root up the seedlings, compact the soil, and leave very few seed to germinate. Goats, by stripping off the leaves and eating the leaders, destroy what few seedlings manage to come up. Both should be excluded during those periods when reproduction is desired.

In logging these forests, cutting is seldom clean enough to allow much reproduction. So far as making provision for reproduction is concerned, it is better to do this by leaving an occasional seed tree of the species desired in the second growth than to adopt a fixed diameter limit. Anything that will reduce the canebrake will also be of great benefit in obtaining reproduction. Small trees should not be cut, and in logging, every effort should be made to save them. Whatever young growth is left on the ground after cutting will form the basis of the next crop of timber, and the seedlings which start at this time form the nucleus of future crops. Waste in lumbering should be avoided, and the stumps should be cut as low as practicable.

Working plans promise to be particularly successful on hardwood bottomland, for the species there are nearly all of rapid growth, and protection from fire is fairly simple. Careful management is strongly advisable, as much of the land when cut over promises to produce worthless woods unless care is taken to leave seed trees and to favor the young growth of desirable species. With proper forest management the land is capable of yielding permanently high returns.

THE MECHANICAL PROPERTIES OF RED GUM WOOD.

By W. Kendrick Hatt, Ph. D.,
Civil Engineer, Bureau of Forestry.

The tests which form the basis of this discussion were made at the timber-testing station of the Bureau of Forestry, at Purdue University, Lafayette, Ind.

STRENGTH OF RED GUM JOISTS.

Owing to the increasing value of the clear, wide lumber, which can be cut from red gum logs, this is, in the main, too expensive a wood for structural uses wherever a supply of pine, fir, or hemlock is available. Nevertheless, red gum is locally used for such building material as joists, sills, and common frames. The material is usually cut from the heart of the tree, which, on account of shakes and defects, is not suitable for other purposes. The supply of red gum timber for such use is so limited that the species is hardly available for general engineering construction. A few joists, sixteen in number, and beams of red gum have, however, been tested. The results are shown in Table IX, to which have been added for comparison the figures derived from tests of loblolly pine, published in Circular 32 of the Bureau of Forestry, and the results of tests on smaller and more perfect sticks of red gum described later in this bulletin.

VALUE OF RED GUM FOR CARRIAGE STOCK.

The large existing supply of red gum and the great percentage of clear wood that is obtained from the logs suggested an investigation to determine if the wood could be steamed and bent into such forms as buggy shafts, and to determine the relative strength of the poorer grades of carriage-stock hickory and specially selected, clear, kiln-dried pieces of red gum. The results of these tests made it apparent that red gum could be bent into shape without difficulty, that it would take a fine finish, and, when properly selected, would hold its shape after being bent. It was soon evident, however, that the specially selected samples of red gum were inferior in strength to even the poorer grades of wood such as hickory, used for carriage stock, and that its use

TABLE IX.—*Comparative strength of green wood of red gum and loblolly pine.*

Species.	Where grown.	Dimensions.	Cross bending.						Compression at right angles to the fiber.	
			Number of tests.	Moisture.	Weight (dry).	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Number of tests.	Crushing strength.
				Per cent.	*Lbs. per cubic ft.*	*Lbs. per sq. inch.*	*Lbs. per sq. inch.*	*1,000 lbs. per sq. inch.*		*Lbs. per sq. inch.*
Red gum	Alabama and Missouri	6″ by 8″ by 16′	1	78.0	28.1	3,819	5,048	1,331		
Do	do	6″ by 8″ by 16′	1	88.1	27.6	3,319	3,964	600		
Do	do	6″ by 6″ by 16′	1	52.7	31.1	3,635	4,005	1,068		
Do	do	6″ by 6″ by 16′	1	68.5	29.4	3,604	4,492	810		
Do	do	6″ by 6″ by 16′	1	95.4	27.6	2,840	3,480	602		
Do	do	6″ by 6″ by 16′	1			2,395	5,060	1,162	1	2,580
Do	do	6″ by 6″ by 16′	1			2,850	4,860	1,105	1	2,490
Do	do	6″ by 6″ by 16′	1			2,785	5,360	1,200	1	2,480
Do	do	6″ by 6″ by 16′	1			2,775	5,550	1,265	1	2,930
Do	do	6″ by 6″ by 16′	1			2,737	5,475	1,230	1	2,980
Do	do	6″ by 6″ by 16′	1			2,370	4,580	1,057	1	2,380
Do	do	6″ by 6″ by 16′	1			2,090	3,230	1,117	1	2,200
Do	do	4″ by 8″ by 16′	1			2,620	4,660	1,110	1	2,630
Do	do	4″ by 8″ by 16′	1			2,340	4,610	1,145	1	2,740
Do	do	4″ by 8″ by 16′	1			2,170	3,260	1,150	1	2,680
Do	do	4″ by 8″ by 16′	1			2,100	4,460	1,048	1	2,575
Do	do		16	Av. [a]**76.5**	[a]**28.7**	**2,608**	**4,570**	**1,075**	11	**2,620**
				Max. 95.4	31.1	3,819	5,550	1,331		2,980
				Min. 52.7	27.6	2,100	3,230	600		2,200
Red gum	Alabama	2″ by 10″ by 16′	2	58.4			4,060			
Do	do	2″ by 10″ by 16′	2	31.2			3,875			
Do	Missouri	4″ by 4″ by 5′	184	Av. [b]**79.1**	**27.1**	**3,875**	**6,200**	**1,233**	202	**2,720**
				Max. 127.5	35.5	5,770	7,860	1,890		3,570
				Min. 32.6	20.3	2,010	4,130	730		1,580
Red gum (clear)	do	2″ by 2″ by 2.5′	62	Av. **71.3**		**3,460**	**6,450**	**1,138**	50	**2,686**
				Max. 104.3		4,840	7,300	1,343		2,970
				Min. 32.5		1,640	5,060	713		2,150
Loblolly pine	Virginia	8″ by 8″ by 16′	15	Av. **72.6**	**26.3**	**1,847**	**3,281**	**729**	13	**1,988**
				Max. 104.6	31.9	3,185	4,720	1,150		2,485
				Min. 61.9	20.0	878	1,545	356		1,362

[a] Determined on 5 sticks.

[b] Determined on 156 sticks.

should be confined to those parts of vehicles that do not have to stand heavy loads and shocks. The modulus of rupture of the poorer grades of carriage-stock hickory, used under such names as XXX and XX, are respectively 22,469 and 20,693 pounds per square inch, determined on 8 test pieces, each 1½ inches in cross section, kiln-dried to about 8 per cent moisture. The clear red gum sticks were 2 by 2 inches in cross section, were kiln-dried to 13.5 per cent of moisture, and exhibited a modulus of rupture of 10,750 pounds per square inch. If this value is adjusted to represent the strength of red gum at 8 per cent moisture, it becomes 15,265 pounds per square inch.

The strength of hickory and red gum varies in almost direct proportion to their respective dry weights or specific gravities.

Because of the ease with which red gum can be bent, and the fact that when properly dried it will hold its shape, it seems that the wood should have an extensive use for such products as bent panels and buggy beds.

TESTS ON STICKS FROM RED GUM BOLTS COLLECTED IN THE FOREST.

In addition to performing the tests described above to determine the availability of red gum for structural use, a fairly comprehensive series of tests, as yet incomplete, has been made to determine in general the mechanical properties of the wood in comparison with that of other species. The relative strength of the sapwood and heartwood at different positions in the trunk, and of wood from different localities, as well as the relation between the strength when green and when dry, and that between the strength of the heartwood of young and of mature trees has been investigated.

Since the great majority of tests that have been made up to the present time, both in the United States and in Europe, to determine the mechanical properties of various species of timber, have been made on pieces 4 by 4 inches in cross section, this size was selected for the general tests. Thus results were secured which may be compared directly with the figures obtained by similar tests elsewhere.

Specimens were tested from two localities—(1) from the Tennessee River bottoms at Hollywood, Ala., about 60 miles south and west of Chattanooga, and (2) from the bottomlands near Risco, in New Madrid County, Mo. A number of bolts from the Santee River bottoms, in South Carolina, were not received in time for the inclusion of the results in the present bulletin.

At Hollywood, Ala., five mature and five immature trees of an average quality were cut, and three logs 16 feet long were taken from each trunk. Planks 4¾ inches thick were sawed at the mill directly lengthwise the trunk, so as to include the center of the heart of the tree, as shown in figure 1. These planks were shipped to the testing station at Lafayette, Ind., and test pieces were sawed from them and dressed down at the mill to 4 by 4 inches in cross section. Cull material, with large checks, excessively crooked grain, knots over three-fourths inch diameter, and rot and shakes, was rejected and not tested. Material from one side of the heart was tested while green. That from the other side was in part kiln dried and in part air dried. The strength of the green sticks is given in this bulletin. It was found quite impracticable to kiln-dry the heartwood in the form of these 4 by 4 sticks. The sapwood, however, was successfully dried. Pieces of heartwood 2 by 2 inches in cross section for the carriage-stock tests were very successfully handled in the dry kiln. Although kept in an open pile outdoors from the first of December, 1903, to the first of April, 1905, the 4 by 4 inch pieces were not, at the end of this time, sufficiently dry for the air-dry tests.

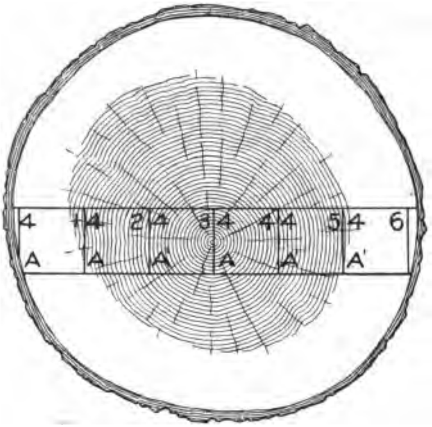


FIG. 1.—Method of taking test pieces from red gum bolts at Hollywood, Ala.

TABLE X.—*Data descriptive of the tested red gum trees from Alabama.*

LOCALITY.—Jackson County, Ala.

ELEVATION.—40 to 60 feet above the Tennessee River.

DRAINAGE.—Poor. Pools of water stand on the flat bottom land three months of the year.

SOIL.—Black organic soil, 3 to 6 inches deep, used principally for growing corn.

FOREST.—Virgin red, black, and tupelo gums; white, red, overcup, and cow oaks; white ash, red maple, hickories, cottonwood, and yellow poplar. Red gum forms about 50 per cent of the merchantable trees.

Tree No.	Class.	Diameter breast-high.	Total height.	Height to first limb.	Height of stump.	Age at stump.	Condition of limbs.	When felled.	When sawed.
		Inches.	*Feet.*	*Feet.*	*Feet.*	*Years.*		1903.	1903.
1	Mature	45.0	109.5	55	2.5	294	Top partially dead.	Sept. 30	Sept. 30
2	.....do......	35.0	106.0	55	3.0	280		....do...	Do.
3	.....do......	29.5	112.5	62	2.5	224		....do...	Do.
4	.....do......	34.0	95.5	56	2.5	232		....do...	Do.
5	.....do......	36.0	108.5	46	2.5	307		....do...	Do.
6	Immature ..	24.0	105.5	59	2.5	170	....	Oct. 1	Oct. 1
7	Mature but suppressed.	21.0	103.5	51	2.5	220	....	....do...	Do.
8	Immature ..	20.0	100.5	49	2.5	....	....	....do...	Do.
9	.....do......	19.5	98.5	52	2.5	....	....	....do...	Do.
10	.....do......	20.5	95.5	52	2.5	184	....	....do...	Do.

From Risco, Mo., bolts were obtained according to the method generally followed in collecting specimens from the forest. Each bolt consisted of a 6-foot section of the trunk, taken far enough above the ground to avoid shakes and rot. The direction of the meridian was marked, and the bolts were shipped to the testing station at Lafayette, Ind., where test pieces were cut out of them, as shown in figure 2. Ten mature and 10 immature trees were cut. In addition, the entire stem of one young tree was cut to furnish the tests reported in Table XV. The trees from Risco, Mo., are probably better than the average to be found in such situations. A description of them is given in Table XII.

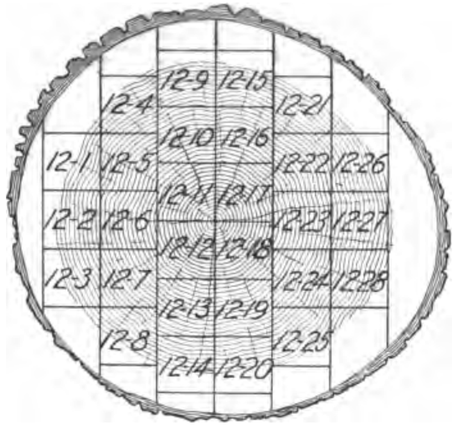


FIG. 2.—Method of taking test pieces from red gum bolts at Risco, Mo.

The strength of the wood was tested in cross bending, that is, as a beam; in compression parallel to the fiber, that is, as a post; and in compression at right angles to the fiber, that is, against such pressure as a steel rail exerts on a railroad tie. The shearing strength along the fiber was also determined. In all cases the moisture in the wood at the time of test was determined by drying out a disk at a temperature of 100° C.

A reference to the detailed meaning of the various terms, and of the methods used in testing the wood and computing the results, will be found in Bulletin No. 8, Timber Physics, Part II, Division of Forestry. It is sufficient now to say that the elastic limit and modulus of rupture are factors which determine the strength of the wood when used as a beam. The modulus of elasticity determines the stiffness of the material when used as a beam. The crushing strength of the wood parallel to the fiber shows the strength of the wood when used as a short post.

The results of the tests on green timber from Hollywood, Ala., and from Risco, Mo., are shown in Table XI.

Table XI.—*Comparative strength of 4 by 4 inch green red gum from Alabama and Missouri.*

Where grown.	Class.	Cross bending.						Compression parallel to the fiber.				
		Number of tests.	Moisture.	Specific gravity (dry).	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Number of tests.	Moisture.	Specific gravity (dry).	Crushing strength. At elastic limit.	Crushing strength. At maximum load.
			Per cent.		*Lbs. per sq. inch.*	*Lbs. per sq. inch.*	*1,000 lbs. per sq. inch.*		*Per cent.*		*Lbs. per sq. inch.*	*Lbs. per sq. inch.*
Hollywood, Ala.	38 per cent sap.	49	Av. [a] **70.0**	**0.464**	**4,091**	**6,219**	**1,116**	45	[b] **60.8**	**0.464**	**2,248**	**2,766**
			Max. 120.7	.562	5,472	8,515	1,710		103.5	.582	3,282	3,932
			Min. 38.0	.362	2,508	4,570	793		37.3	.391	1,410	1,833
Risco, Mo	10 per cent sap.	184	Av. [c] **79.1**	**.434**	**3,875**	**6,200**	**1,233**	202	[d] **62.4**	**.481**	......	**2,720**
			Max. 127.5	.568	5,770	7,860	1,890		140.0	.615	......	3,570
			Min. 32.6	.326	2,010	4,130	730		35.9	.362	......	1,580

[a] Moisture on 44 sticks.
[b] Moisture on 15 sticks.
[c] Moisture on 156 sticks.
[d] Moisture on 42 sticks.

The tests from the Hollywood trees, Table XI, include all pieces from the three logs in the stem of each tree. The modulus of rupture under cross bending of the test pieces, excluding culls, taken from the three positions is, on the average, 6,380 for the butt log, 6,150 for the middle log, and 6,080 for the top log.

Separating the results of the tests from the Risco trees, Table XI, so as to compare the strength of the wood from the old trees and the young trees, we have the following statement:

Table XII.—*Comparative strength of 4 by 4 inch green mature and immature red gum, from Risco, Mo.*

Class.	Cross bending.				Compression parallel to the fiber.	
	Number of tests.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Number of tests.	Crushing strength, maximum load.
		Lbs. per sq. inch.	*Lbs. per sq. inch.*	*1,000 lbs. per sq. inch.*		*Lbs. per sq. inch.*
Immature:						
Average	38	**3,900**	**6,370**	**1,335**	42	**2,790**
Maximum		5,770	7,710	1,890		3,570
Minimum		2,660	5,030	921		1,700
Mature:						
Average	146	**3,860**	**6,150**	**1,215**	160	**2,710**
Maximum		5,460	7,860	1,590		3,350
Minimum		2,010	4,130	730		1,580

TABLE XIII.—*Data descriptive of the tested red gum trees from Missouri.*

NOTE: Strength values apply to green wood. Number of tests are for compression tests.
LOCALITY.—New Madrid County, Mo.
ELEVATION.—10 to 20 feet above the Mississippi River.
DRAINAGE.—Poor. Pools of water stand on the flat bottom land half the year or longer.

SOIL.—Rich, black organic soil, 3 to 6 inches deep. Subsoil a fertile black sand, locally known as "blue gumbo" soil. It is excellent for cotton growing, and yields 30 or more bushels of corn per acre.

FOREST.—Uniformly dense; virgin red and black gums; white, red, overcup, yellow, and cow oaks; winged and cork elms; white ash, red maple; mockernut and shagbark hickories; sassafras, papaw, coffee tree, red-osier dogwood, box elder, catalpa, hackberry, and cottonwood.

Red gum forms about 75 per cent of the merchantable trees. The reproduction of red gum is very poor, of white ash excellent, of the oaks poor.

Tree No.	Class.	Diameter breasthigh.	Total height.	Height to first limb.	Diameter at first limb.	Height above stump of lower end of bolt.	Height of stump.	Diameter at stump.	Age at stump.	Condition of stump.	Condition of limbs.	Form of stem.	When felled.	When sawed.	Cross-bending strength.				Crushing strength parallel to the fiber.
															Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Number of tests.	
		Inch.	*Ft.*	*Ft.*	*Inch.*	*Feet.*	*Feet.*	*Inch.*	*Yrs.*				1904.	1904.	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*		*Lbs. per sq. in.*
1	Overmature ...	37.5	127	62	26.0	12.0	3.0	40.8	253	Sound, slight ringshake.	Broken, dead in top.	Straight	Feb. 11	Feb. 11	4,282	6,489	1,290	17	2,974
2	.....do	38.5	137	66	32.2	25.0	3.7	40.0	250	.....do	Top slightly doty.	Slightly crooked.	Feb. 17	Feb. 17	3,383	6,187	1,123	20	2,565
3	.....do	36.0	118	45	27.5	13.0	3.0	37.8	a 240	Rotten	Broken, rotten in top.	Straight	Feb. 11	Feb. 11	3,662	6,012	1,190	16	2,651
4	.....do	41.5	137	68	28.2	45.0	3.7	46.0	286	Very slight windshake.	Top slightly doty.	.....do	Feb. 17	Feb. 17	3,844	6,183	1,202	12	2,312
5	.....do	36.0	124	51	27.4	18.5	3.5	39.0	......	Hollow	Top partially dead.	Slightly crooked.	Feb. 12	Feb. 12	4,554	6,940	1,392	16	3,000
6	.....do	36.1	136	65	23.5	12.5	3.5	38.0	240	Sound, slight windshake.	.....do	Fairly straight...	...do ...	...do ...	4,244	6,359	1,233	9	2,825
7	.....do	38.0	118	60	26.5	15.0	3.8	40.0	......	Hollow	Decayed and broken in top.	.....do	...do ...	...do ...	4,332	6,830	1,366	12	2,968
8	.....do	39.0	112	57	27.5	12.4	3.3	42.0	260	Slight fire-scar and windshake.	Top fairly sound.	Rather crooked..	...do ...	...do ...	3,631	5,770	1,084	18	2,782

9	.....do.........	35.5	110	49	27.0	17.4	3.7	37.5	......	Rotten.........	Dead stubs in top.	Straight.........	Feb. 13	Feb. 13	3,724	6,050	1,245	15	2,290
10	.....do.........	40.7	120	65	27.2	25.7	3.5	42.0	253	Severe ringshake.	Doty, hollow top	Fairly straight...	Feb. 17	Feb. 17	3,226	5,423	1,086	19	2,340
11	Immature.....	17.7	105	51	12.0	9.1	3.6	19.1	64	Slight ringshake.	Sound..........	Slightly crooked.	Feb. 16	Feb. 16	4,075	6,465	1,383	3	2,816
12	Mature, but suppressed.	21.0	106	41	15.1	9.0	3.4	22.4	*a* 200	Very doty.....	Top slightly doty.	.....do..........	...do...	...do...	3,540	6,143	1,248	4	2,696
13	Immature.....	18.6	95	35	14.0	24.0	3.0	19.1	125	Sound, ringshake.	Sound..........	.....do..........	...do...	...do...	3,637	6,555	1,509	4	2,842
14	.....do.........	23.2	118	50	15.9	22.0	2.8	27.3	......	Fire hollow....	.....do..........	.....do..........	...do...	...do...	4,118	6,772	1,416	6	3,031
15	.....do.........	22.1	100	57	13.5	11.4	2.8	24.8	......	Hollow........	Top slightly doty.	Fairly straight...	...do...	...do...	3,932	6,337	1,330	4	2,809
16	.....do.........	21.2	87	51	13.5	10.0	3.6	21.5	190	Sound.........	Sound..........	Straight.........	Feb. 18	Feb. 18	3,380	5,718	1,156	5	2,540
17	Mature, but suppressed.	20.8	80	40	16.0	14.4	4.4	20.8	236	Sound, slight ringshake.	Rotten in top...	Crooked.........	...do...	...do...	3,718	6,215	1,363	5	2,790
18	Immature.....	18.6	98	30	13.7	10.0	3.6	19.6	147	Sound.........	Sound..........	Straight.........	...do...	...do...	5,197	7,066	1,326	3	3,323
19	.....do.........	20.0	90	44	14.7	22.5	4.0	20.6	158	Slightly doty and windshaken.	Top fairly sound.	Crooked.........	...do...	...do...	3,515	5,562	1,159	4	2,584
20	.....do.........	15.9	103	25	12.5	11.2	3.3	16.4	89	Sound.........	Sound..........	Straight.........	...do...	...do...	4,655	7,065	1,592	2	3,290

a Approximated.

The comparative strength of the sapwood and the heartwood is shown by Table XIV. In the case of the Risco sticks the heart pieces contained 85 per cent or more of heartwood, and the sap contained 85 per cent or more of sapwood. In the case of the Hollywood sticks these percentages were 85 and 70, respectively.

TABLE XIV.—*Comparative strength of 4 by 4 inch green red gum heartwood and sapwood.*

Where grown.	Class.	Cross bending.							Compression parallel to fiber.					
		Number of tests.							Number of tests.					
		Moisture.	Strength.	Moisture.	Specific gravity (dry).	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Moisture.	Strength.	Moisture.	Specific gravity (dry).	Elastic limit.	Crushing strength
				Per cent.		*Lbs. per sq. inch.*	*Lbs. per sq. inch.*	*1,000 lbs. per sq. in.*			*Per cent.*		*Lbs. per sq. inch.*	*Lbs. per sq. inch.*
Hollywood, Ala	Heart:													
	Av	22	26	**86.4**	**0.486**	**4,049**	**6,176**	**1,110**	6	21	**70.9**	**0.492**	**2,316**	**2,718**
	Max			120.7	.562	4,742	8,515	1,591			103.5	.582	2,911	3,446
	Min			52.8	.422	2,508	4,693	830			47.1	.419	1,573	2,058
	Sap:													
	Av	15	16	**54.5**	**0.480**	**4,250**	**6,341**	**1,139**	7	15	**51.1**	**0.453**	**2,322**	**2,933**
	Max			93.4	.497	5,472	8,212	1,361			80.0	.506	2,958	3,625
	Min			38.0	.362	2,994	5,177	790			37.3	.391	1,631	2,367
Risco, Mo	Heart:													
	Av	95	102	**83.3**	**0.432**	**3,825**	**6,140**	**1,223**	26	128	**55.2**	**0.483**	....	**2,698**
	Max			111.4	.517	5,460	7,690	1,590			91.2	.600	....	3,570
	Min			41.6	.338	2,130	4,600	912			25.9	.431	....	1,530
	Sap:													
	Av	9	11	**87.3**	**0.454**	**4,380**	**6,640**	**1,314**	6	8	**86.7**	**0.468**	....	**3,054**
	Max			111.2	.513	5,770	7,710	1,890			140.0	.531	....	3,570
	Min			65.4	.419	2,660	4,240	730			67.5	.362	....	2,250

The results of 103 tests of the strength in compression at right angles to the fiber show the following results:

Green wood from Risco, Mo.:	Pounds per square inch.
Average strength	639
Maximum strength	940
Minimum strength	480

The results of 95 tests of the shearing strength along the fiber in the direction of the radius show the following results:

Green wood from Risco, Mo.:	Pounds per square inch.
Average radial shearing strength	686
Maximum radial shearing strength	986
Minimum radial shearing strength	501

The results of 97 tests to determine the shearing strength along the fiber tangential to the annual rings show the following results:

Green wood from Risco, Mo.:	Pounds per square inch.
Average tangential shearing strength	810
Maximum tangential shearing strength	1,008
Minimum tangential shearing strength	515

The results of 66 tests in cross bending and compression to show the difference in strength at different heights in the stem of a tree are presented in Table XV. These test pieces were 2 by 2 inches in cross section and were taken from the young sap tree referred to on page 44.

TABLE XV.—*Comparative strength of 2 by 2 inch clear, green sap pieces cut from various parts of a young red gum tree.*

[Moisture, 100 per cent.]

Height above ground in tree.	Cross-bending strength.				Crushing strength parallel to the fiber.
	Number of tests.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	
Feet.		*Lbs. per sq. inch.*	*Lbs. per sq. inch.*	*1,000 lbs. per sq. inch.*	*Lbs. per sq. inch.*
6	10	3,323	6,474	1,071	2,632
9	10	3,618	7,023	1,212	2,790
12	9	3,603	7,180	1,381	2,916
15	8	3,858	7,502	1,227	2,931
18	7	3,927	7,467	1,453	3,101
21	6	4,094	7,066	1,306	3,081
24	2	4,257	7,465	1,290	2,950
27	6	3,700	7,183	1,160	2,962
30	3	3,416	6,100	1,211	2,904
33	3	3,431	6,376	1,071	2,843
36	2	3,492	6,145	1,038	2,725

A summary of the strength of the green wood as disclosed by the tests quoted above will be as follows:

- Cross-bending, 233 tests:
  - Modulus of rupture, 6,204 pounds per square inch.
  - Fiber stress at elastic limit, 3,920 pounds per square inch.
  - Modulus of elasticity, 1,208,000 pounds per square inch.
- Compression parallel to fiber, 247 tests:
  - Crushing strength, 2,731 pounds per square inch.
- Compression perpendicular to fiber, 103 tests:[a]
  - Crushing strength at elastic limit, 639 pounds per square inch.
- Shearing strength:[a]
  - In radial direction, 95 tests, 686 pounds per square inch.
  - In tangential direction, 97 tests, 810 pounds per square inch.

WEIGHT OF RED GUM WOOD.

The average specific gravity of dry red gum, as determined for the pieces whose strength is given in Table XI, is 0.440, equivalent to 27.5 pounds per cubic foot. The volume entering into the calculations, however, is the exact volume of the green wood at the time of the test. Thus the shrinkage is not taken into account. The actual weight of the dry wood is about 10 per cent greater than the values quoted, or 30.2 pounds per cubic foot. Red gum containing 15 per cent of moisture weighs about 32.4 pounds per cubic foot, and this figure may be taken as the weight of the wood when thoroughly air dried. This figure must not be confused with the "dry weight" of the lumber as fixed by the various lumber associations, since that applies to material which is only partially dry. The weight of green wood from Hollywood, Ala., is, on an average, 49.2 pounds per cubic foot, with a maximum of 66 pounds per cubic foot, and a minimum of 38.8 pounds per cubic foot.

---

[a] Compression perpendicular to the grain and shearing tests on wood from Risco, Mo., only.

RESISTANCE TO ABRASION.

The resistance of red gum to an abrasive action on the end of the fiber was determined by pressing blocks of the wood against a revolving disk covered with a form of sandpaper known as Garnet paper. The amount worn from the end of the block was taken to be a measure of the hardness of the wood in this respect. The proper abrasive, speed of disk, pressure, etc., were found after considerable preliminary experimentation. The hardness of red gum across the ends of the fibers, as thus determined, is between that of yellow poplar and sugar maple. Taking the hardness of red gum as unity, yellow poplar may be graded as 0.5 and sugar maple as 1.7. These results are only incidental to a general investigation of this subject through abrasive tests.

THE STRUCTURE OF RED GUM WOOD.

In its external appearance red gum wood presents a fine-grained, smooth, close texture. The surface indication is of a straight grain, but when the wood is broken, the lines of fracture generally run in unexpected ways, and not with the apparent direction of the growth. It is a fairly tough wood, and when tested in cross-breaking does not break short or brashy, but with a fair degree of splintering. Notwithstanding this, it has little resilience, whereas wood like hickory is both tough and resilient. The wood near the butt of the tree often contains bundles of fibers of varied and reversed obliquity of direction of growth. When broken under torsion—that is, under a twisting action—this structure produces an almost conchoidal fracture. The actual internal twist of the fibers is also evident in the wavy or folded appearance of the split surface of the wood. Ordinarily, however, the wood does not present this oblique, twisted grain in so marked a degree. Figure 3 shows the character of fracture of red gum in contrast with that of hickory.

It is doubtless this unevenness in the direction of the grain that renders so much of the wood difficult to dry without twisting, when not held under pressure.

Very much of the heartwood presents characteristic banded markings of pleasing varied light-red and chocolate colors.

The following account of the microscopic structure of red gum wood is contributed by Mr. H. D. Tiemann, engineer of tests of the timber-testing station of the Bureau of Forestry at the Yale Forest School:

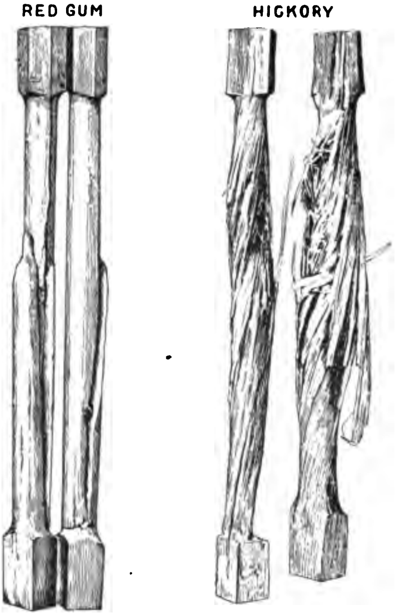


Fig. 3.—Characteristic fractures of red gum and hickory under torsion test.

Red gum belongs to the heterogeneous group of woods. It is of the diffuse porous type; that is to say, the pores (which can be seen by the unaided eye in the cross section) are quite uniform and regularly distributed, there being little or no perceptible difference in this respect between the early and the late wood of each year's growth. For this reason the annual rings are not distinctly marked, as they are, for example, in the chestnut, which is a wood of the other type, having the pores of the early wood very much larger and more numerous than those of the late wood. Moreover, the wood fibers of red gum show very little difference between the early and late wood. The medullary rays are comparatively fine and numerous, and are fairly uniform in size. The reddish-brown coloring matter appears chiefly in small particles in the medullary rays, but all the tissues are stained. Gum occurs in the rays and in the vessels or pores.

The wood is made up chiefly of three different kinds of elements: (1) Wood fiber, (2) the vessels or ducts which form the pores, (3) the medullary rays.

The fibers and ducts are arranged vertically, like hollow columns tightly cemented together, and the medullary rays interlace them at right angles, being radially horizontal. These rays necessarily separate the columns where they intersperse them, but the latter are reunited above and below the interstices where the rays pass through.

The different elements are shown in the figures, which were made from careful microscopic examinations of a piece of red gum heartwood. The dimensions were accurately traced, and are indicated by a scale. Figure 4 represents a cross section highly magnified, showing the fibers (F) and the ducts (D) between the two medullary rays (M). Figure 7 shows a cross section of one of these rays, and also the manner in which the columns separate in order to allow the ray to pass through—in this case a fiber on the right and a duct on the left. Figure 6 illustrates the three principal elements in their relative sizes and proportions, and figure 5, portions of these elements highly magnified.

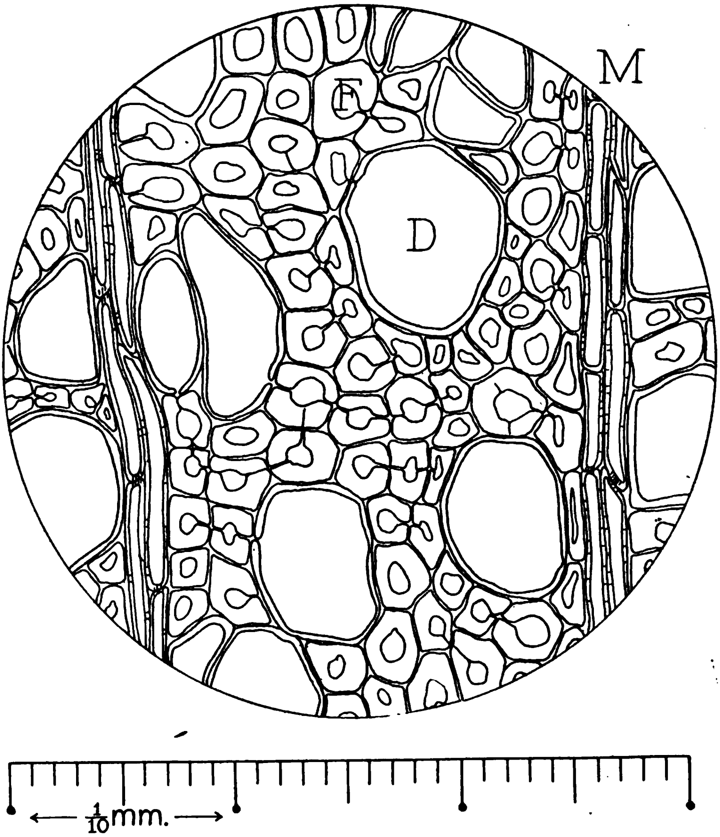


FIG. 4.—Cross section of red gum wood, showing the structure. F, wood fiber; D, duct or vessel (trachea); M, medullary ray cells.

THE WOOD FIBERS.

The wood fibers are hair-like cells with sharp, tapering ends and very thick walls. They form the chief body of the wood structure. Their size and appearance are shown in the drawings, in which they are designated throughout by F. In length the fibers vary from 1.4 mm. to 2.4 mm.,[a] and are about one-fiftieth as wide, or from 0.02 to 0.04 mm. Nine-tenths of the cross section is occupied by the solid, thickened wall. The wall is pierced by numerous minute slit-like holes or "pits."

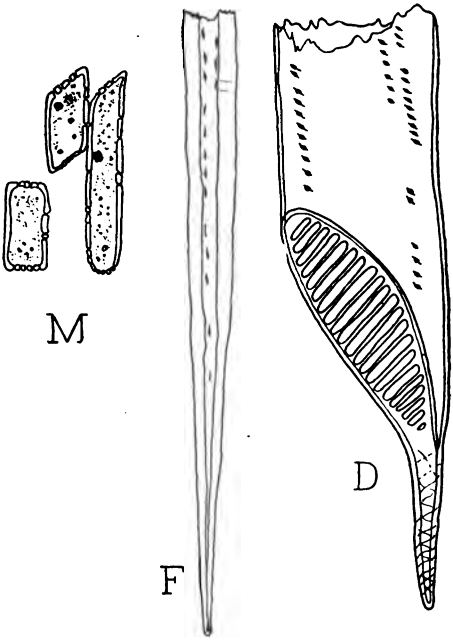


Fig. 5.—Highly magnified portions of the elements of red gum wood. D, end of a duct or vessel (trachea) showing the peculiar grating; F, pointed end of a fiber; M, short medullary ray cells. The narrow slit-like pits are seen in the walls of each element.

THE DUCTS OR VESSELS.

The ducts or vessels, which are technically known as tracheæ, are hollow, tube-like cells, very much larger in diameter than the fibers, but not so long, and with very thin walls. They form the "pores" of the wood, which conduct liquids readily and cause the wood to absorb water rapidly. They are spliced together end to end and open into one another through a remarkably regular grating of parallel slots shown in D, figures 5 and 7.

The walls, which are comparatively very thin (0.003 mm.), are pierced by numerous fine, lance-shaped holes or pits, and sometimes by large bordered pits (see D, figs. 5 and 7). The ends often terminate in a long, finger-like extension, giving them a curious appearance. This extension resembles the fibers somewhat, but has spiral markings.

The ducts vary in length from about 1 to 1.75 mm., and are about one-fifteenth as wide, or from 0.07 to 0.12 mm. The pores occupy about one-third of the total cross-sectional area of the wood.

THE MEDULLARY RAYS.

The medullary rays are composed of very short, thin-walled cells with blunt ends, their interiors communicating through minute pits in the walls. In the live wood these cells contain living protoplasm and various organic substances and pigments. Figure 6, M, shows a group of these medullary ray cells, and figure 5, M, some of the cells highly magnified. In diameter they are about the same as the wood fibers, but many of them are not more than twice as long as they are wide. Some have flat, others oblique ends.

---

[a] 1 mm. (millimeter) is about one twenty-fifth of an inch.

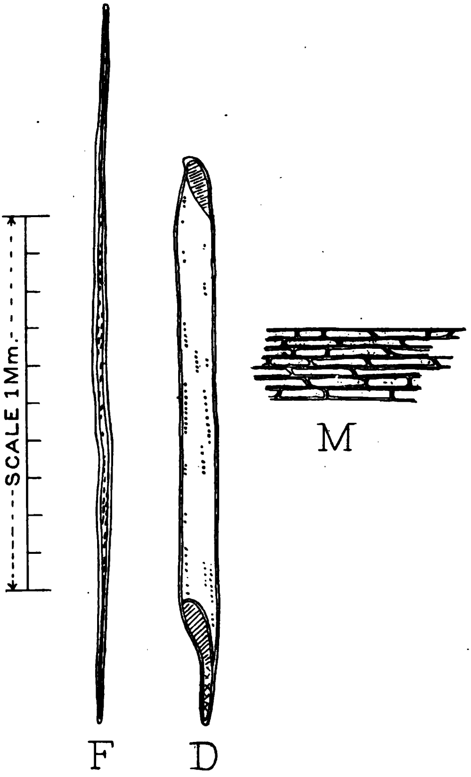


FIG. 6.—Comparative sizes of the wood elements of red gum. F, wood fiber; D, duct or vessel (trachea); M, medullary ray cells.

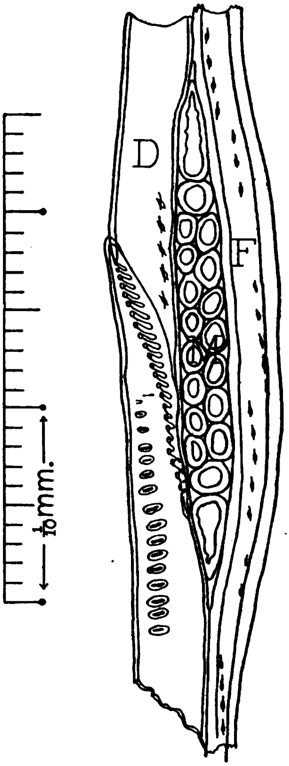


FIG. 7.—Cross section of a medullary ray in red gum, M, with a wood fiber, F, on one side and a duct or vessel, D, on the other.

The medullary rays are usually composed of two horizontal rows, and from 10 to 40, averaging about 20, vertical rows of these cells. Figure 7 is a cross section of one ray. The rays are about 0.03 mm. thick and from 0.2 to 0.7 mm. high. They are very numerous and quite evenly distributed. In the specimen examined there were from 7 to 10 rays per millimeter of the cross section of the wood.

INDEX.

Page.

Abrasion tests of red gum wood 50
Black gum, distribution and habitat 9
    uses 8
Compression tests of red gum wood, and results 41–49
Cost of producing red gum lumber 24
Cross-bending tests of red gum wood, and results 41–49
Export trade in red gum lumber 19, 20
Fires, effects on forests containing red gum 15
Forest management for hardwood bottomlands of the South 36–39
Fungi attacking red gum, number of species 16
Germination of red gum seeds 14
Girdling red gum to increase heartwood, practice now abandoned 18
Gum, species important in the South 8
Hardwood bottomlands of the South, character and crops 10
        classification 37–39
        forest management 36–39
    bottoms in the Mississippi Valley, types 10, 11
        on the Atlantic coast, description 11
    species associated with red gum 10–12
    timberlands in Mississippi Valley, prices 17
Height and clear length of red gum trees 29
Hogs and goats, ranging in forests a drawback to reproduction 16, 39
Insect injury to red gum trees 16
Intolerance of shade, characteristic of red gum 12, 13
Lands, hardwood bottoms in the South, classes 37–39
        values 37
Logging of red gum, use of railroad, method and cost 18
    tupelo gum, methods and difficulties 27
Lumbering of red gum, drying out the sap to reduce weight of logs 17
        methods employed 17–19
        present field of operations 18
    tupelo gum 26–28
Medullary rays, red gum wood 53
Merchantable lumber in red gum trees of given diameters 31
Milling of red gum 24
Prices of red gum logs 21
        lumber 23
    tupelo gum 28
Properties of red gum wood, cross-bending tests and results 41–49
        crushing strength, tests and results 41–49
        intrinsic qualities affecting utility 22, 23
        mechanical, tests and results 40–49
    tupelo gum wood 27, 28

Page.

- Red gum, age in South Carolina and Missouri ... 30
  - associated species ... 10–12
  - characteristics of tree ... 12–15
  - distribution and habitat ... 8, 9
  - for finishing wood, increase of demand ... 7, 18, 19
  - hostile influences ... 15, 16
  - joists, strength ... 40
  - lands, character and elevation ... 9, 10
  - lumber, grades and percentages of each ... 24
    - market and uses ... 19–22
  - rate of growth in South Carolina and Missouri ... 28–30
  - wood, properties ... 22, 23, 40–49
    - resistance to abrasion ... 50
    - structure ... 50–53
    - value for carriage stock ... 40
- Reproduction of hardwood species in the South ... 38, 39
- Reproductive habits of red gum ... 13, 14
- Root system of red gum ... 12
- Sapwood of red gum, increase in value ... 17
    - trees, larger percentage on Atlantic coast ... 10, 17
  - percentage in red gum in South Carolina and Missouri ... 31, 32
- Seasoning red gum lumber ... 24–26
- Second growth, number of trees per acre of red gum and associated species ... 35, 36
  - red gum, occurrence and value ... 15
- Seedlings of red gum, needs and habits of growth ... 14
- Stand of red gum and other species in virgin hardwood bottoms ... 32–35
  - on second-growth hardwood bottomland ... 35, 36
- Strength tests of red gum ... 40, 41
- Structure of red gum wood, fibers ... 52, 53
  - medullary rays ... 53–54
  - microscopic ... 51, 52
  - toughness, resilience, torsion tests ... 50, 51
- Stumpage, red gum, values ... 17
- Timberlands of the South, control by large real estate companies ... 16
- Timber, standing, red gum, values ... 17
- Tests of mechanical properties of red gum, methods and results ... 40–49
- Tupelo gum, distribution and habitat ... 9, 13, 26, 27
  - extent of present lumbering operations ... 27
  - lumbering, manufacture, and uses ... 26–28
  - methods and difficulties of logging ... 27
    - of handling ... 28
- Uses of red gum lumber ... 19, 22, 40, 41
  - tupelo gum lumber ... 27, 28
- Volume of red gum, calculated by the Doyle-Scribner log rule ... 30–36
- Weight of red gum wood ... 49, 50
- Windfalls of red gum, not common ... 15

O